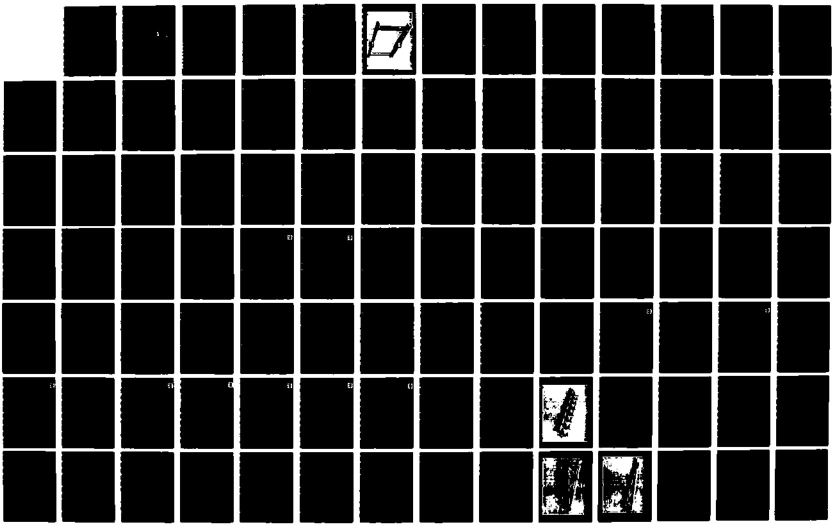
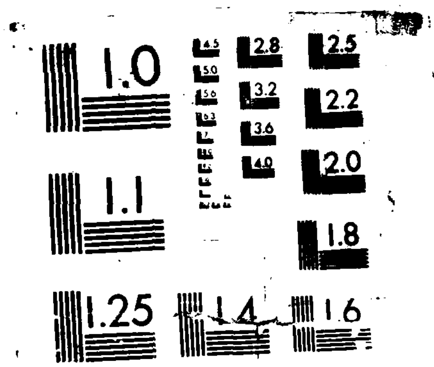
AD-A183 988 LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN NORTHERN ORDNANCE DIV R RATHE ET AL APR 87 1/3

UNCLASSIFIED FMC-E-3041-VOL-D1-PT-2 DAAA21-86-C-0047 F/G 19/6 NL





MICROCOPY RESOLUTION TEST CHART

(2)

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AD-A183 988

Lightweight Towed Howitzer Demonstrator

Final Report

Volume D1 - Part II

Structural Analysis

(Less Cradle and System)

April 1987

Contract Number DAAA21-86-C-0047

FMC CORPORATION
Northern Ordnance Division
4800 East River Road
Minneapolis, Minnesota 55421

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*
155mm towed gun howitzer, advanced weapons, composite cradle, composite hydraulic actuators, composite trails, field artillery weapon, firing stability analysis, howitzers, hydraulic control valves with force feedback, hydraulic joystick control of gun direction, hydraulic inertial rammer, hydraulic opening breech, hydraulic primer autoloader, ~~lightweight towed howitzer demonstrator (LTHD),~~ load out of battery howitzer, mortar howitzer, recoil energy recovery, recoil mechanism, ~~using~~ metal matrix composites, titanium muzzle brake, titanium platform, titanium spade, titanium walking beams, thermal stability, towing stability analysis, unconventional weapons ~~and weight reduction of artillery~~

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The LTHD (Lightweight Towed Howitzer Demonstrator) was to be a 9,000 lb equivalent to the M198, transportable via Blackhawk helicopter, with reduced emplacement time using fewer personnel. The FMC design achieved weight reduction via a mortar-like configuration, composites structure, and hydraulic actuators. Recovery of power from the recoil system, in turn, facilitated crew reduction via hydraulic emplacement, four-way joystick tube lay, and power ramming. FMC completed Concept Development (Ph I) and two-thirds of Detailed Design (Ph II) prior to funds running out.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

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PART NUMBERS: 12585800, Platform Weldment
12585801, Platform Machining

DESCRIPTION:

The platform is a machined titanium weldment and has a current weight of 352.9 lbs. Major load paths through the platform include: the upper and lower sections of the gimbal via Torrington bearings; the spade attachment on the platform bottom; the slinging provision attachment on the sides of the top platform section; the trails at each side and the traverse cylinder at the lower rear of the platform.

In addition to the platform design being driven by the loading constraints, the shape is driven by C130 envelope constraints and also the clearances required during gimbal (and fire control linkage) traverse.

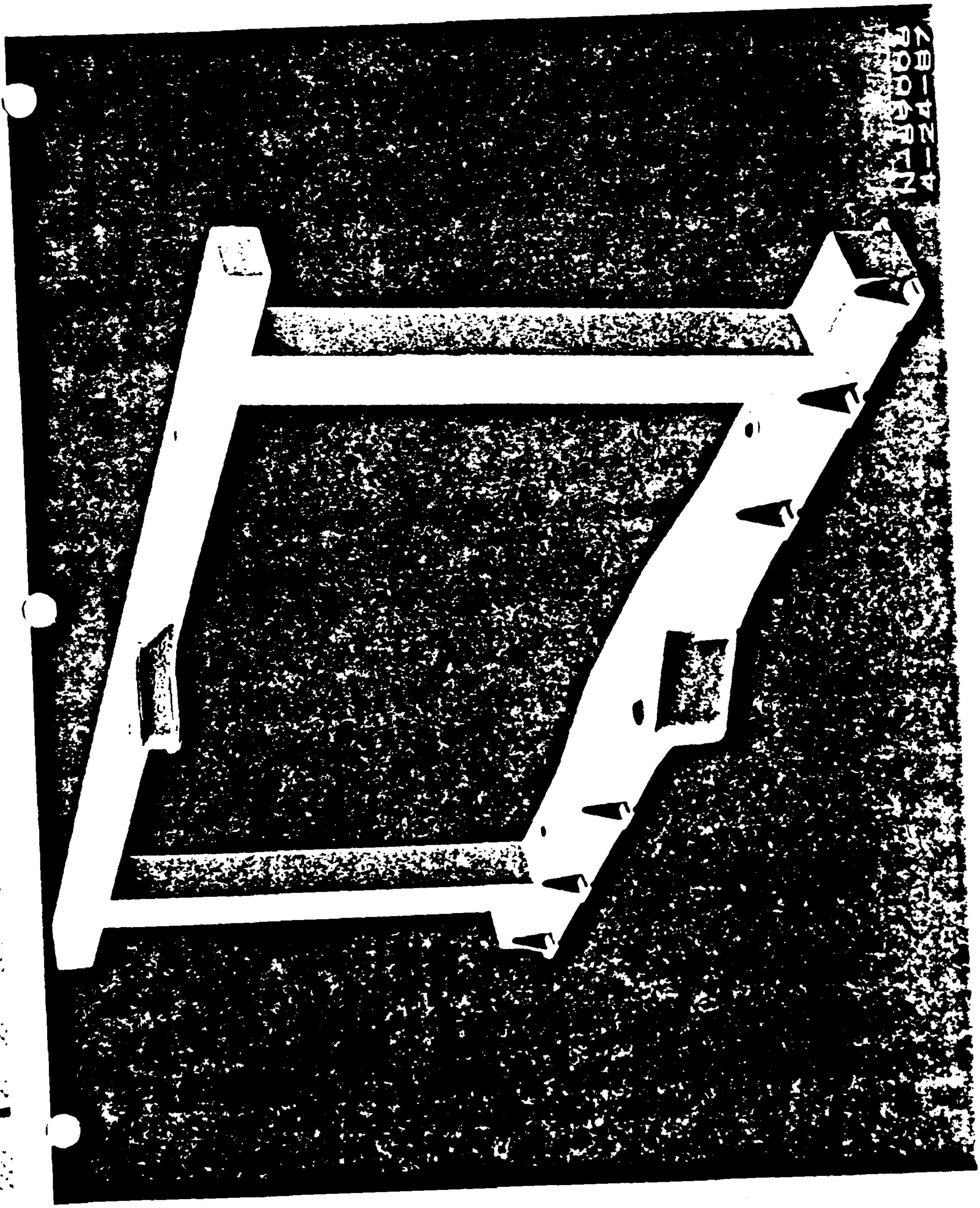
A design approach similar to that of the gimbal was taken with the platform in efforts to minimize weight. Efforts to date have been to minimize the weight of the platform by generating an optimum configuration throught the use of FEA models and hand calculations. Further weight reductions were envisioned by planned structural testing.

A summary of platform load conditions and structural calculations can be found in the following pages of this section.

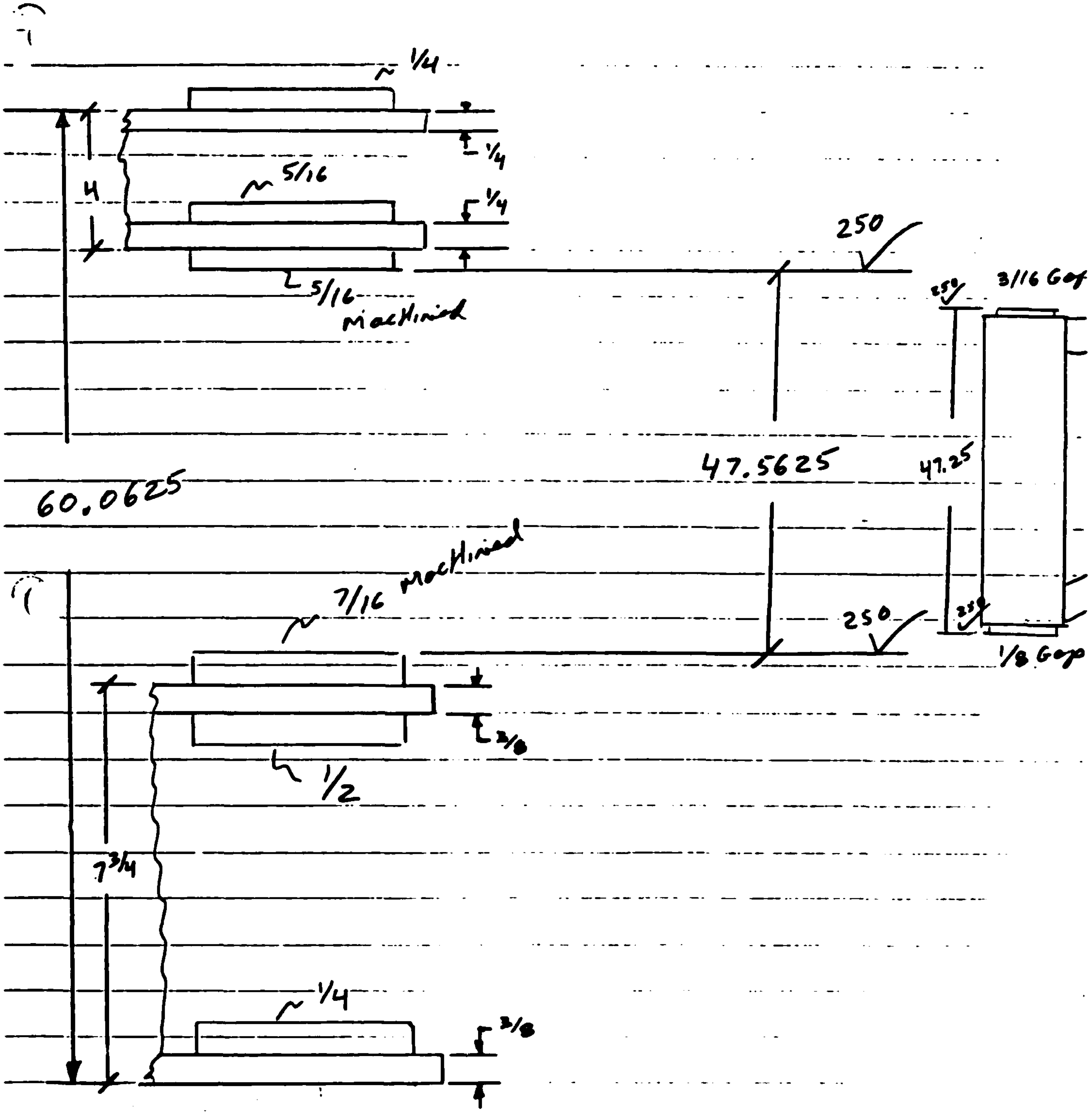
STATUS:

All design and drawing requirements for the platform have been completed. Drawings for the platform are found in the TDP.

AUTHORS: Dave Langerud, Patty Yelich

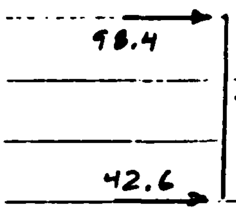


Platform Hubs



Platform / Gimbal Pins - Hubs, Bearing Stress

Bottom Pin Dia = 3"



$128 \times .3 = 38.4$

$38.4 = \dfrac{141}{3\ t}$; $t = 1.224$

use 1.25 3/8 Plt ∴ 2 - 7/16 Hubs

Check welds

Hub OD = 6" $l = \pi D = 18.85"$

$\beta = \dfrac{141}{3(1.25)} = 37.6$

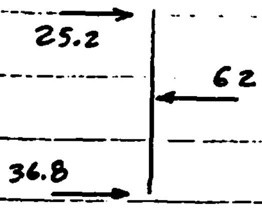
$f_w = [141\ (7/16/1.25)]/18.85 = 2.62$ Kip/in

$\frac{1}{4}\nabla$ $f_A = 120(\cos 45) .3\ (.25) = 6.36$ Kip/in

$38.4 = \dfrac{42.6}{3\ t}$; $t = .37$

$\beta = \dfrac{42.6}{3(.625)} = 22.7$ current .375 Plt + 1/4" Hub ∴ OK

Top Pin Dia = 2"



$38.4 = \frac{62}{2t}$; $t = .8073$

$.8073 - .25 = .5573/2 \quad .2786$

use 5/16 Hubs ∴ t = .875

$\frac{3}{16}$ V $f_A = 4.77$ Kip/in

$f_w = 62(5/16/.875)/\pi 4 = 1.76$

∴ OK

$\beta = \frac{62}{2(.875)} = 35.4$ KSI

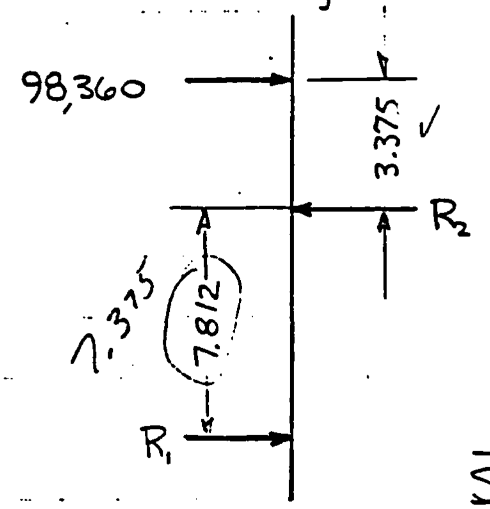
$38.4 = \frac{36.8}{2t}$; $t = .4792$

1/4" PLt 1/4" HuB

$\beta = \frac{36.8}{2(.5)} = 36.8$ KSI

bottom bearing – GIMBAL 3" Dia

T 11/18/86



$R_2(7.812) = 98360(11.19)$

$R_2 = 140,900$ — = 103.4

$R_1 = 42,540$

$\overline{S_y = 100,000 \text{ psi}}$ $\sigma = \frac{Mc}{I}$

solid shaft $I = \frac{\pi d^4}{64}$ $c = \frac{d}{2}$

assume S.F. = 1.8

$56,000 = \frac{M(32)}{\pi d^3}$

at 0° QE:

bottom bearing: $M = 98360(3.375)$

$= 332$ in-kip $d = \left[\frac{M(32)}{\pi(56000)}\right]^{.33}$

$d = 3.86$

shaft = 4.0"

maragingsteel $\frac{S_y = 320,000 \text{ psi}}{\text{S.F.} = 1.8}$ $\left[\frac{332000\ (32)}{\pi\ (178,000)}\right]^{.33} = d$

$d = 2.64$

shaft = 3.0"

titanium $\frac{\overset{\text{H.T.}\ 150,000}{S_y = 120,000 \text{ psi}}}{\text{S.F.} = 1.8}$ $\left[\frac{332,000(32)}{\pi(67,000)}\right]^{.33} = d$ D = 2.0

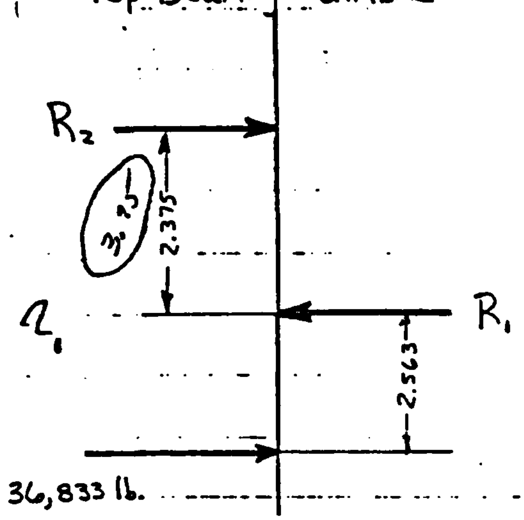
$d = 3.65$

shaft = 4.0"

7

2" Dia

Top bearing – GIMBAL



$36{,}833\,(4.938) = R_1\,(2.375)$

$R_1 = 76581$ → 62.00 ?

$R_2 = 39748$ 25,2 ?

$M = 36833\,(2.563) = 94403$ in-lbs.

shaft length = 10 in.

$V = .7854\,h\,(D^2 - d^2)$

$S_u = 280{,}000$

S.F. = 1.8 $\qquad Z = \dfrac{94403}{156{,}000} = .605 = \dfrac{\pi\,(D^4 - d^4)}{32\,D}$

$D = 2.0$, $d = 3.675^{.25}$

$d = 1.385$, $t = \dfrac{2 - 1.385}{2} = .308$, $Wt = 7.854\,(4 - 1.385^2)(.282) = 4.6$

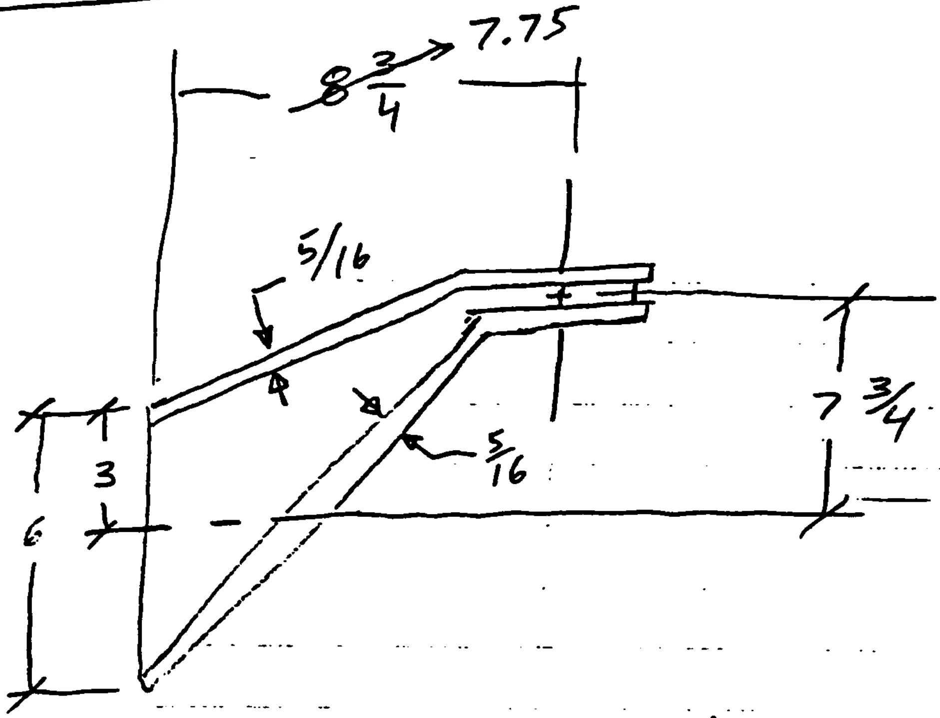
$D = 2.5$ $\quad d = 23.66^{.25}$

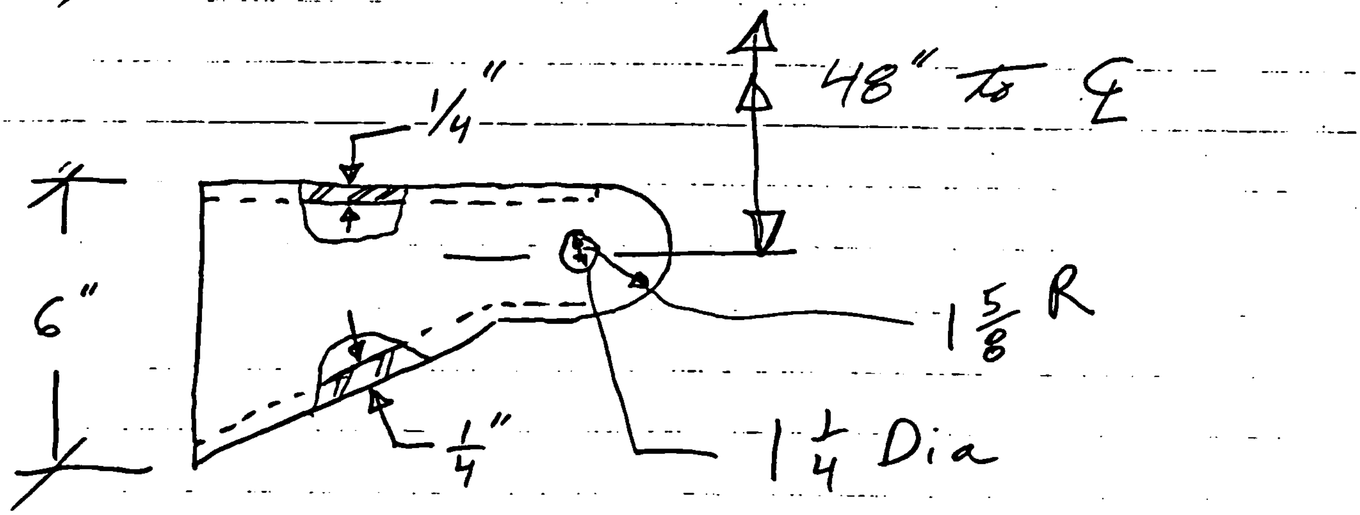
$d = 2.205$, $t = \dfrac{2.5 - 2.2}{2} = .147$, $Wt = 7.854\,(2.5^2 - 2.205^2)(.282) = 3.1$ lbs

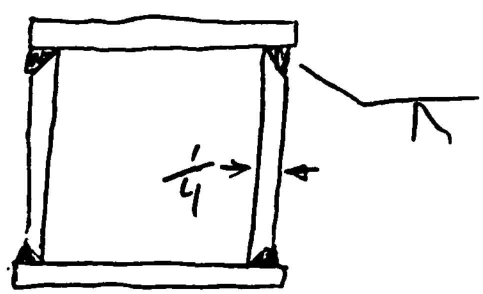
$D = 3.0$, $d = 62.51^{.25}$

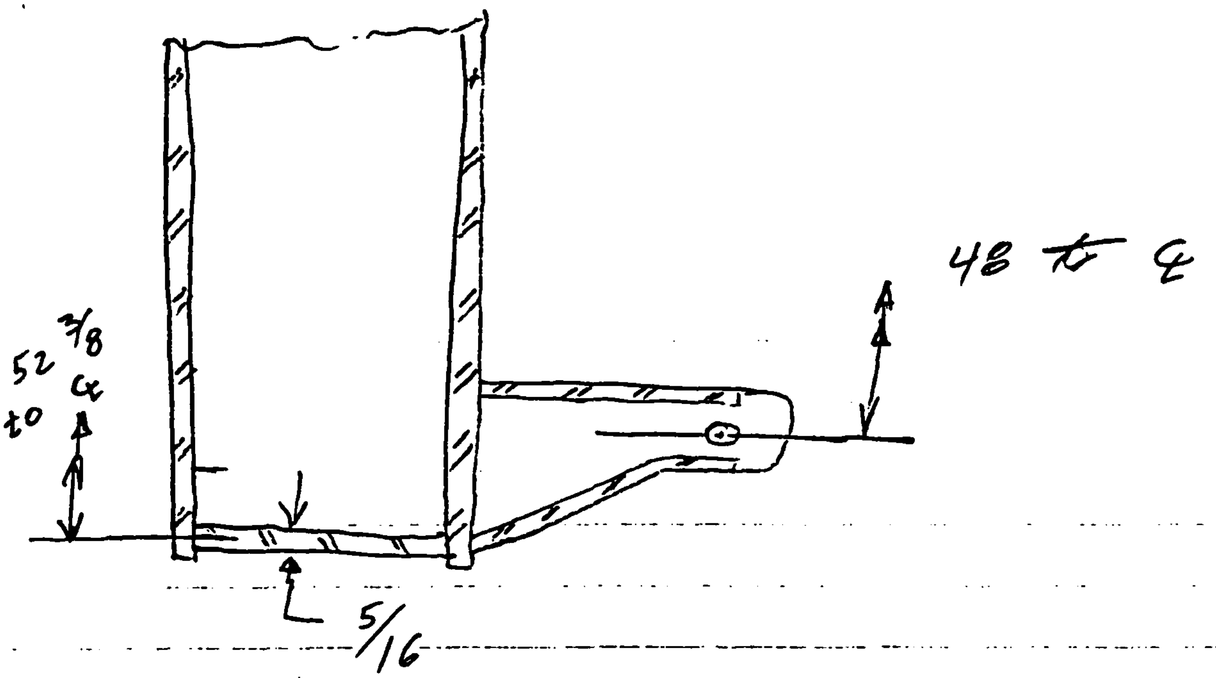
$d = 2.81$ $\qquad t = \dfrac{3.0 - 2.81}{2} = .094$, $Wt = 7.854\,(9 - 2.81^2)(.282) = 2.4$ lb.

Traverse Cylinder Lug





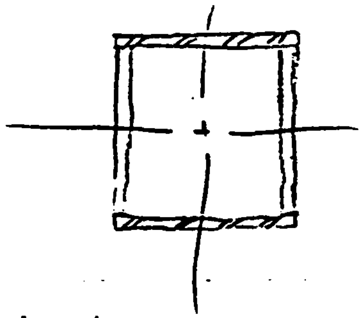



48 to ℄
52 3/8 to ℄
5/16

Traverse Log

$M = .26\,(8.75) = 227.5$

$T' = 26\,(7.75) = 201.5$



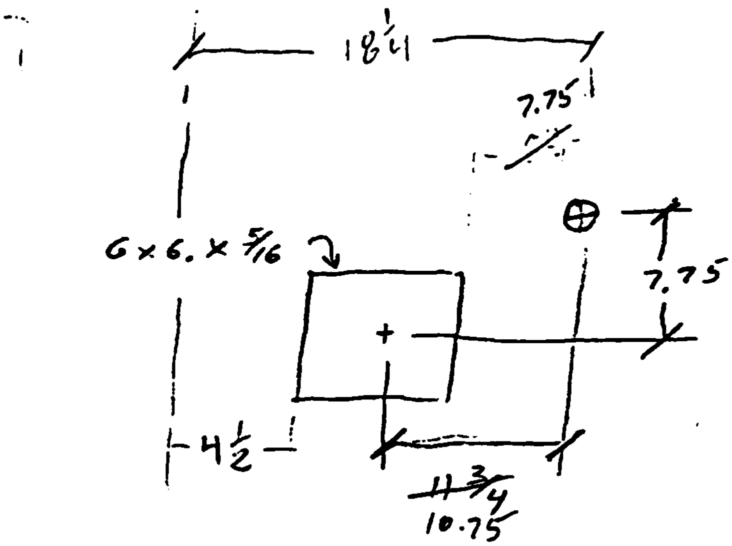
$$\tau = \frac{201.5}{2(5.69)^2(.31)} + \frac{3}{2}\,\frac{26}{\cancel{2}(.625)(6)}$$

$\tau = 20$

Top; Bottom

$$Z = \frac{.625\,(6)^2}{6} = 3.75$$

$$\sigma = \frac{227.6}{3.75} = 61\ KSI$$



Check Box $M_1 = \overset{26}{\cancel{38}}(7.75) = \cancel{387.5}\ 201.5$

$M_2 = \overset{26}{\cancel{50}}(\cancel{11.75}\ 10.75) = \cancel{587.5}\ \cancel{305.5} \rightarrow 279.5$

$\sigma = \frac{\overset{201.5}{387.5}}{12.8} + \frac{\overset{279.5\ \cancel{305.5}}{587.5}}{12.8} + \frac{\overset{26}{50}}{7.1} = \overset{15.7}{\cancel{30.3}} + \overset{21.8\ \cancel{23.9}}{\cancel{45.9}} + \overset{3.7}{\cancel{7.0}} = \overset{41.2\ \cancel{43.3}}{\cancel{83.2}}$

+ Bending & Torque Due To Spade Loads

NOTE: 26 (18.5) = 481 in Kip @ ℄ of Gimbal
Applied Load = 509 in Loads Model
Arm 6.75 → 11.75

1.74 = 2.49

4.25 + 1.38 = 5.625 → 7.75

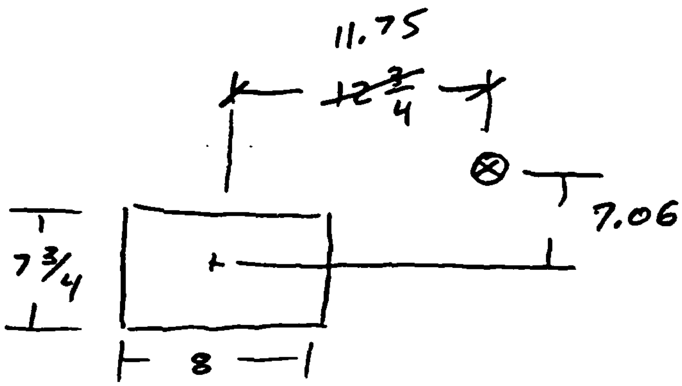
1.17 =

35 → 50

1.43 = 1.67

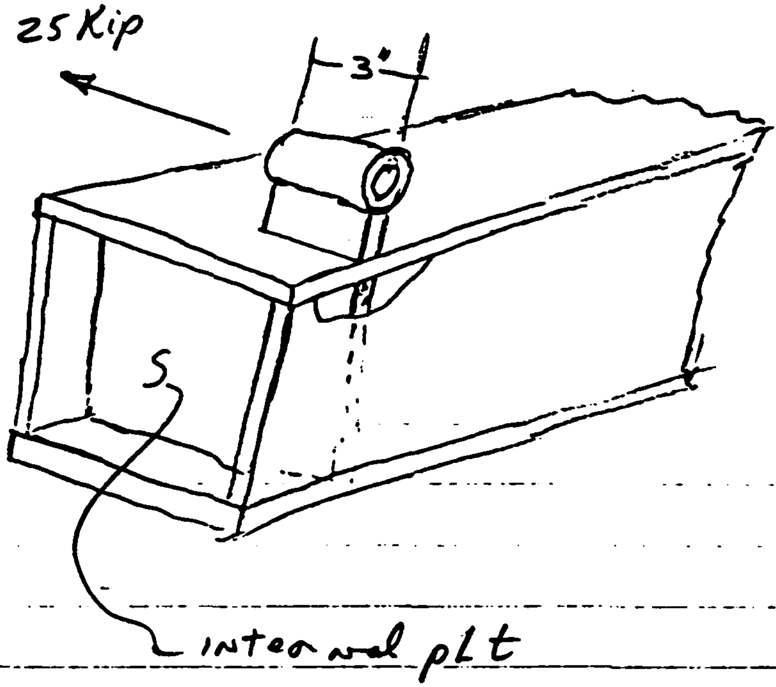
36 x 6.75 = 243
?? x 11.75 = 587

40%

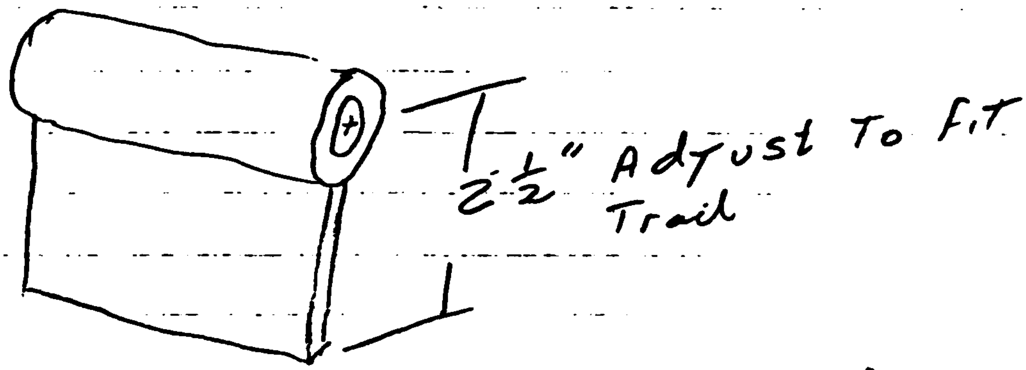


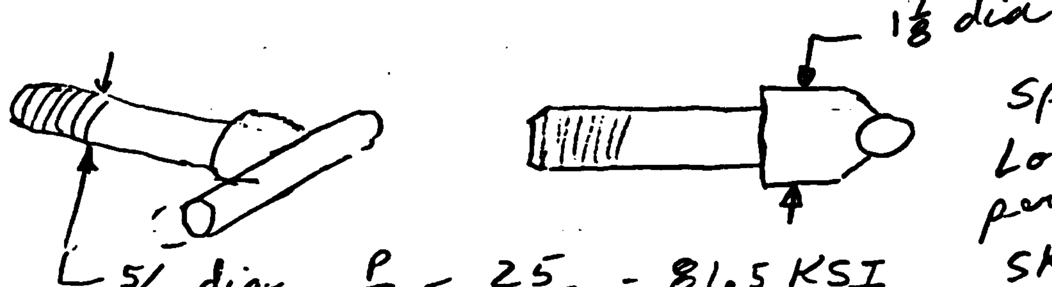
$$\sigma = \frac{\overset{26}{\cancel{50}}\,(\overset{11.75}{\cancel{12.75}})}{25.6} + \frac{\overset{26}{\cancel{50}}\,(7.06)}{24.15} + \frac{\overset{26}{\cancel{50}}}{10.37} = \overset{11.9}{24.8} + \overset{7.6}{14.6} + \overset{2.5}{4.8}$$

$$= \cancel{44.23}\ \ 22.0$$



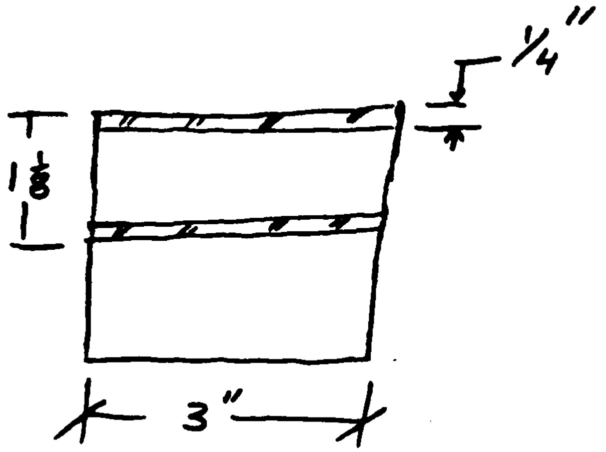
6x6x.312

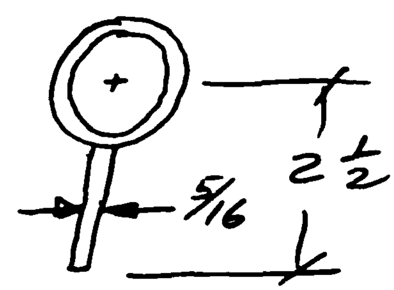




Spring Loaded per Borts sketch

$\frac{P}{A} = \frac{25}{.3068} = 81.5$ KSI





$M = 25(2.5)$ $Z = \frac{.25(3)^2}{6} = \cancel{2.25} \; .4688$

$\sigma = 28$ KSI Bend

$\tau = \frac{3}{2}\frac{(25)}{3(.25)} = 50$ KSI $\tau_{yield} = 72$

SF = 1.44

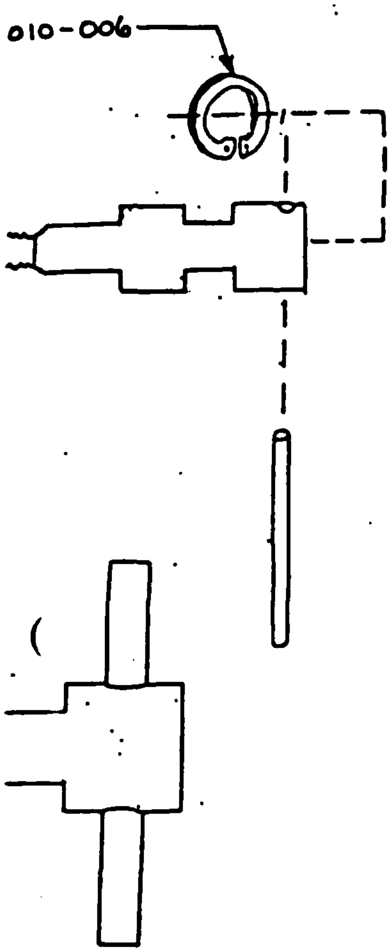
Try $t = .312$

$\tau = \frac{3}{2}\frac{(25)}{3(.312)} = 40$ KSI SF = 1.80

$\sigma = \quad 133$

15

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL



REF. DWG.	DESCRIPTION

PART NO.

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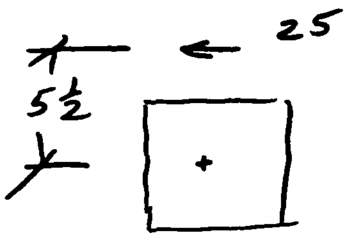
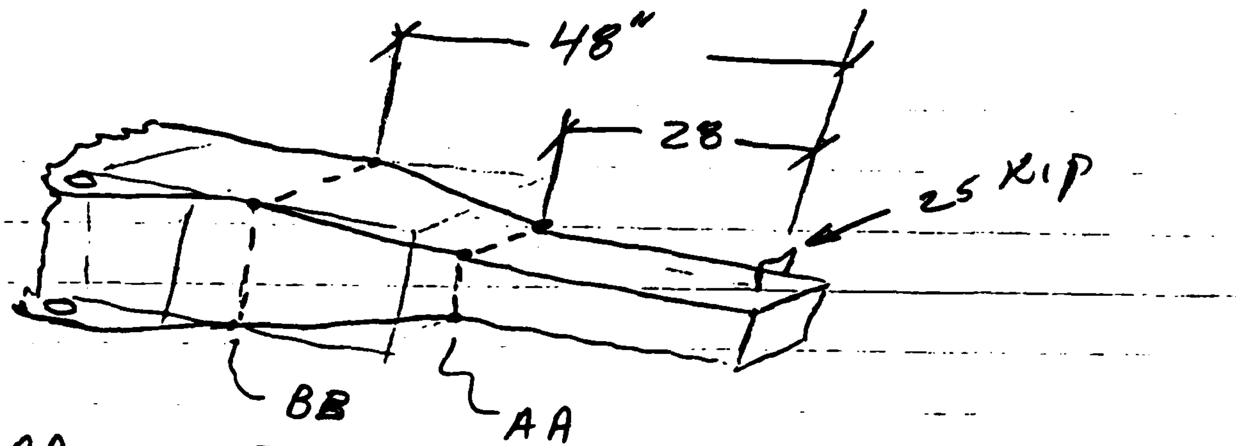
DRAFTSMAN B. ANDERSON / CHECKER	TRAIL ASSEMBLY TO SYSTEM
ENGR / ENGR	
ENGR / ENGR	
SIZE B	FSCM NO. 19200 — T-12585710-595/A
SCALE	UNIT WT. — SHEET 4 OF 4

cHeck Box



$$\tau = \frac{5.5(25)}{2(5.688)^2(.312)} + \frac{3}{2}\,\frac{(25)}{2(6)(.312)}$$

$$\tau = 17 \text{ KSI}$$



Sec AA $6 \times 6 \times 5/16$

$$\sigma = \frac{25(28)}{12.8} = 54.7 \text{ KSI}$$

Sec BB

$$\sigma = \frac{25(48)}{24.15} = 49.7 \text{ KSI}$$

Trail Connections; cBom 131, 132, 155, 156
$V = \emptyset, 1, \emptyset$

Grid	M_1	M_2	V_1	V_2	P	T	
							5Kp ; Bump
131	—	—	.968	-4.49	—	—	
132	—	—	1.61	-4.80	—	—	
154	—	—	-2.39	-3.45	7.57	—	
156	—	—	1.2	-3.99	7.55	—	
							4 ½ G's
131	—	—	-3.76	-10.52	—	—	
132	—	—	-3.76	-10.52	—	—	
154	—	—	-2.68	-7.47	-15.8	—	
156	—	—	2.6	-7.5	15.8	—	
							22 ½ Trav
130	—	—	4.85	—	—	—	∅ @E
131	—	—	5.19	-14.0	—	—	Down wt
[illegible]	—	—	5.96	-11.6	—	—	
[illegible]3	—	—	-2.32	—	—	—	
154	—	—	-10.0	-14.0	-3.18	—	
156	—	—	8.28	-11.57	-2.62	—	

cBooms 202, 302 $V = 0, 1, 0$

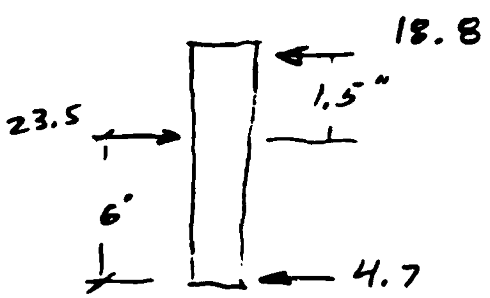
Grid	M_1	M_2	V_1	V_2	P	T	
							5 ; B
203	—	—	—	.87	.60	—	
303	—	—	.31	4.8	.6	—	
							4 ½
203	—	—	-.15	3.96	1.66	—	
303	—	—	.11	3.89	1.70	—	

5/16 Hub

5/16 plt

Trail / Platform Pivot Pins

$\sqrt{10^2 + 14^2}\left(\frac{3.5}{3.2}\right) = 18.8$



M = 28.2 In Kip

V = 18.8 Kip

1" OD 1/4" wall

$I = (.5^4 - .25^4)\frac{\pi}{4} = .046$

Z = .092 σ = 306

1 1/4 OD × 1/4 wall

$I = (.625^2 - .375^2)\frac{\pi}{4} = .1043$

Z = .1669

σ = 169. KSI

1 3/8 × 3/8

$I = (.6875^4 - .3125^4)\frac{\pi}{4} = .1680$

Z = .2443

σ = 115

1 1/2 × 3/8

$I = (.75^4 - .375^4)\frac{\pi}{4} = .2330$

Z = .3106

σ = 91

1 5/8 × 3/8 wall

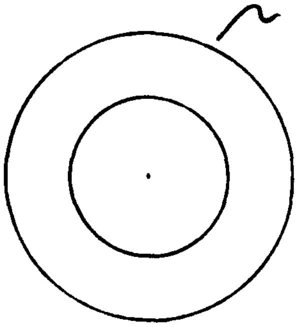
$I = (.8125^4 - .4375^4)\frac{\pi}{4} = .3135$

Z = .3859

σ = 73.08 KSI

A = 1.4726

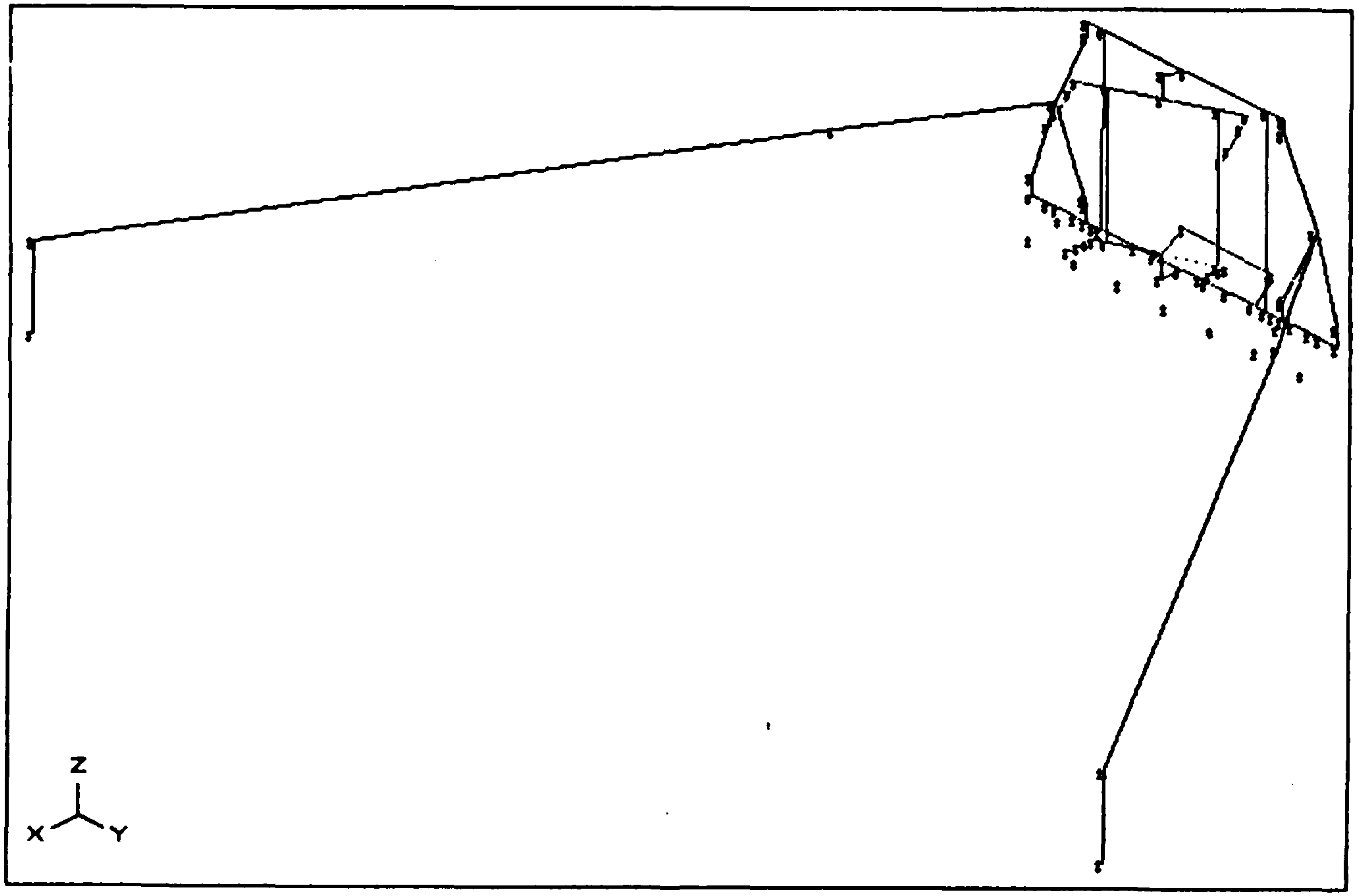
$\tau = \frac{2(18.8)}{1.4726} = 25.5$ KSI



1 5/8 OD × 3/8 wall

SDRC_ I-DEAS 2.5B: Model Creation 28-JAN-87 12:48:44

LTWO



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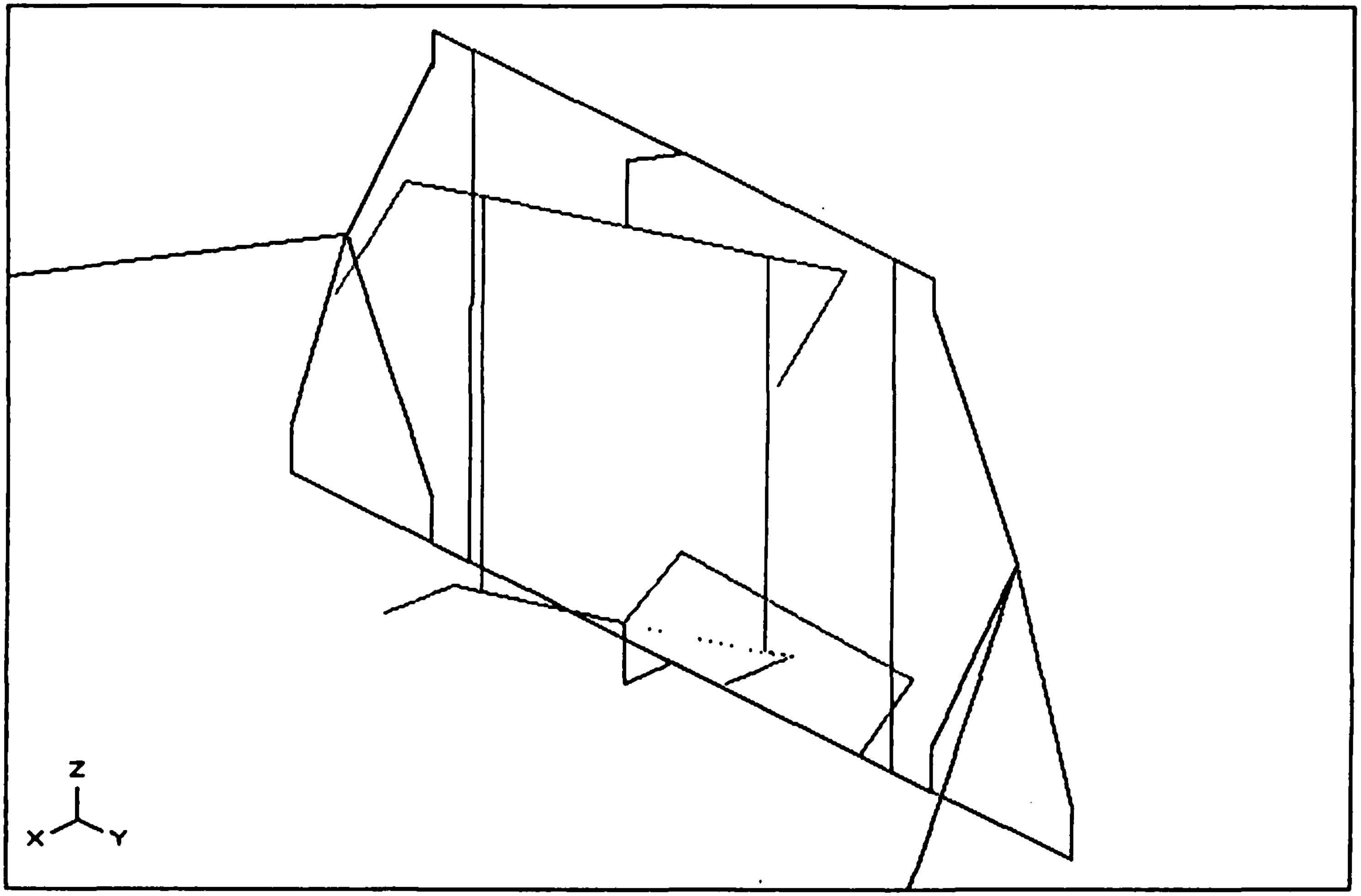
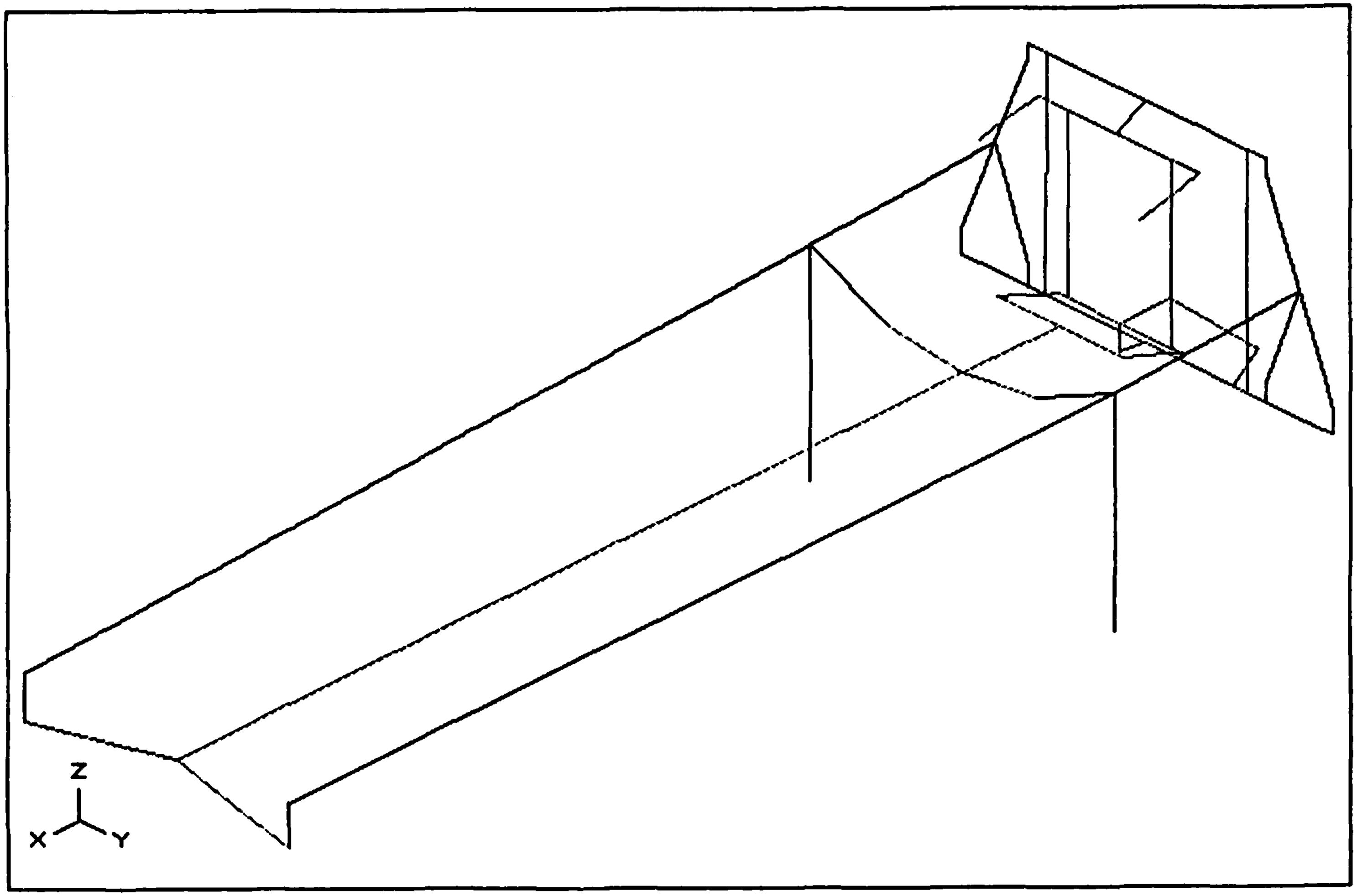
LTWO



SDRC__I-DEAS 2.5B: Model Creation 29-JAN-87 11:56:56

LTHD TRAVEL



TOP BEAM CBoom 142, 143, 144, 145 V = 1, 0, 0

.6 x 1/4 A = 4.75 I_1 = 23.47 I_2 = 12.35
Z_1 = 7.82 Z_2 = 6.17

GRID	M_1	M_2	V_1	V_2	P	T	
142	—	9.5	-3.3	.76	2.4	-13.4	φ, φ
143	17.5	5.5	-3.3	.76	2.4	-13.4	
143	149.7	-105.7	8.5	-2.9	-3.1	14.2	
144	-83.5	-26.7	8.5	2.9	3.1	14.2	
144	-172.6	28.2	9.2	-2.9	8.8	-67.4	
145	79.3	107.1	9.2	-2.9	8.8	-67.4	
145	31.2	10.0	5.9	-1.3	4.3	23.8	
146	—	17.1	5.9	-1.3	4.3	23.8	
142	—	-56.8	19.8	-4.5	-14.2	79.2	φ, 72
143	104.φ	-33.2	19.8	-4.5	-14.2	79.2	
143	56.7	-55.4	18.6	-1.4	-17.9	78.6	
[illegible]	-454.9	-26.6	18.6	-1.4	-17.9	78.6	
4	-482.6	-9.6	-19.2	-1.0	-14.2	-96.1	
145	45.1	19.2	-19.2	-1.0	-14.2	-96.1	
145	-96.8	-30.9	-18.4	4.2	-13.2	-73.8	
146	—	-52.9	-18.4	4.2	-13.2	-73.8	
142	—	14.4	-5.1	1.2	3.6	-20.4	22½, φ
143	26.8	8.3	-5.1	1.2	3.6	-20.4	
143	134.8	170.5	4.9	4.6	5.9	-9.0	
144	-.8	-44.5	4.9	-4.6	-5.9	-9.0	
144	-133.7	37.3	-6.8	-4.6	11.8	-63.φ	
145	53.9	16.3	-6.8	-4.6	11.8	-63.φ	
145	40.φ	12.8	7.6	-1.7	5.5	30.5	
146	—	21.8	7.6	-1.7	5.5	30.5	

TOP BEAM CONT'D

[illegible]	M_1	M_2	V_1	V_2	P	T	
142	—	-56.1	19.5	-4.4	-14.2	78.0	22½, 72
143	-102.4	-32.9	19.5	-4.4	-14.0	78.0	
143	85.5	-186.6	15.8	-4.6	-24.1	37.9	
144	-350.ϕ	-80.5	15.8	-4.6	-24.1	37.9	
144	-483.3	21.9	-17.5	-4.6	-6.3	-116.4	
145	1.ϕ	148.ϕ	-17.5	-4.6	-6.3	-116.4	
145	-81.3	-26.ϕ	-15.5	3.5	-11.1	-61.9	
146	—	-44.4	-15.5	3.5	-11.1	-61.9	
142	—	-9.5	3.4	-7.6	-2.4	13.8	SKIP : BUMP
143	-18.1	30.2	3.4	-7.6	-2.4	13.8	
143	2.6	1.9	2.6	—	-3.8	13.8	
144	-69.2	-.2	2.6	—	-3.8	13.8	
144	-78.2	5.3	-3.0	—	-2.6	-12.0	
145	3.7	3.2	-3.0	—	-2.6	-12.ϕ	
[illegible]	-20.9	35.0	-4.0	7.6	-1.2	-16.ϕ	
[illegible]	—	-4.7	-4.0	7.6	-1.2	-16.ϕ	
142	—	-10.7	7.5	-15.8	-2.7	29.9	4½ G's
143	-39.2	72.4	7.5	-15.8	-2.7	29.9	
143	8.3	7.0	5.6	—	5.7	25.9	
144	-144.5	5.7	5.6	—	5.7	25.9	
144	-145.5	6.3	-5.6	—	-5.5	-25.7	
145	8.8	5.0	-5.6	—	-5.5	-25.7	
145	-39.3	72.6	-7.5	15.8	-2.6	-3ϕ.ϕ	
146	—	-10.3	-7.5	15.8	-2.6	-30.0	

TOP BEAM

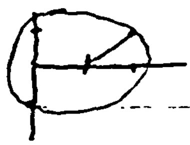
$$\cdot = \frac{85.5}{7.82} + \frac{186.6}{6.17} + \frac{24.1}{4.75} = 46.2$$

$$\sigma = \frac{350}{7.82} + \frac{80.5}{6.17} + \frac{24.1}{4.75} = 62.9$$

$$\sigma = \frac{483.3}{7.82} + \frac{21.9}{6.17} + \frac{6.3}{4.75} = 66.7 \quad ①$$

$$\tau = \frac{116.4}{2(3.75)(5.75)(.25)} + \frac{3}{2}\,\frac{6.3}{2} = 15.5 \quad ②$$

combine ① & ②



$$c = \frac{66.7}{2} = 33.35$$

$$r = \sqrt{33.35^2 + 15.5^2} = 36.8$$

$$\sigma_I = c + r = 70.1$$

TOP BEAM CONT'D

GRID	M_1	M_2	V_1	V_2	P	T	
							22½, 72
142	—	-56.1	19.5	-4.4	-14.2	78.0	
143	-102.4	-32.9	19.5	-4.4	-14.0	78.0	
143	85.5	-186.6	158.2	-4.6	-24.1	37.9	
144	-350.0	-80.5	158.2	-4.6	-24.1	37.9	
144	-483.3	21.9	-17.5	-4.6	-6.3	-116.4	
145	1.0	148.0	-17.5	-4.6	-6.3	-116.4	
145	-81.3	-26.0	-15.5	3.5	-11.1	-61.9	
146	—	-44.4	-15.5	3.5	-11.1	-61.9	
142	—	-9.5	3.4	-7.6	-2.4	13.8	SKIP : BUMP
143	-18.1	30.2	3.4	-7.6	-2.4	13.8	
143	2.6	1.9	2.6	—	-3.8	13.8	
144	-69.2	-.2	2.6	—	-3.8	13.8	
144	-78.2	5.3	-3.0	—	-2.6	-12.0	
145	3.7	3.2	-3.0	—	-2.6	-12.0	
145	-20.9	35.0	-4.0	7.6	-1.2	-16.0	
[illegible]	—	-4.7	-4.0	7.6	-1.2	-16.0	
142	—	-10.7	7.5	-15.8	-2.7	29.9	4½ G's
143	-39.2	72.4	7.5	-15.8	-2.7	29.9	
143	8.3	7.0	5.6	—	5.7	25.9	
144	-144.5	5.7	5.6	—	5.7	25.9	
144	-145.5	6.3	-5.6	—	-5.5	-25.7	
145	8.8	5.0	-5.6	—	-5.5	-25.7	
145	-39.3	72.6	-7.5	15.8	-2.6	-30.0	
146	—	-10.3	-7.5	15.8	-2.6	-30.0	

TOP BEAM CBeam 142, 143, 144, 145 $V = 1, 0, 0$

6 x 1/4 $A = 4.75$ $I_1 = 23.47$ $I_2 = 12.35$

$Z_1 = 7.82$ $Z_2 = 6.17$

GRID	M_1	M_2	V_1	V_2	P	T	
142	—	9.5	-3.3	.76	2.4	-13.4	Ø, Ø
143	17.5	5.5	-3.3	.76	2.4	-13.4	
143	149.7	-105.7	8.5	-2.9	-3.1	14.2	
144	-83.5	-26.7	8.5	2.9	3.1	14.2	
144	-172.6	28.2	9.2	-2.9	8.8	-67.4	
145	79.3	107.1	9.2	-2.9	8.8	-67.4	
145	31.2	10.0	5.9	-1.3	4.3	23.8	
146	—	17.1	5.9	-1.3	4.3	23.8	
142	—	-56.8	19.8	-4.5	-14.2	79.2	Ø, 72
143	104.Ø	-33.2	19.8	-4.5	-14.2	79.2	
143	56.7	-55.4	18.6	-1.4	-17.9	78.6	
144	-454.9	-26.6	18.6	-1.4	-17.9	78.6	
[illegible]	-482.6	-9.6	-19.2	-1.0	-14.2	-96.1	
145	45.1	19.2	-19.2	-1.0	-14.2	-96.1	
145	-96.8	-30.9	-18.4	4.2	-13.2	-73.8	
146	—	-52.9	-18.4	4.2	-13.2	-73.8	
142	—	14.4	-5.1	1.2	3.6	-20.4	$22\frac{1}{2}$, Ø
143	26.8	8.3	-5.1	1.2	3.6	-20.4	
143	134.8	170.5	4.9	4.6	5.9	-9.0	
144	-.8	-44.6	4.9	-4.6	-5.9	-9.0	
144	-133.7	37.3	-6.8	-4.6	11.8	-63.Ø	
145	53.9	16.3	-6.8	-4.6	11.8	-63.Ø	
145	40.Ø	12.8	7.6	-1.7	5.5	30.5	
146	—	21.8	7.6	-1.7	5.5	30.5	

COLUMNS

$$\sigma = \frac{192.4}{10.58} + \frac{627.1}{10.58} + \frac{3.63}{5.75} = 78.\ \text{KSI}$$

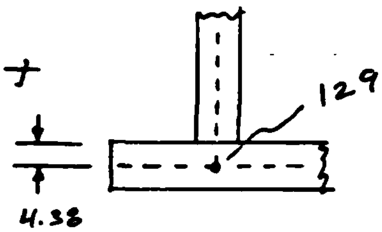
$$\sigma = \frac{151.8}{10.58} + \frac{745.6}{10.58} + \frac{1.55}{5.75} = 85\ \text{KSI}$$

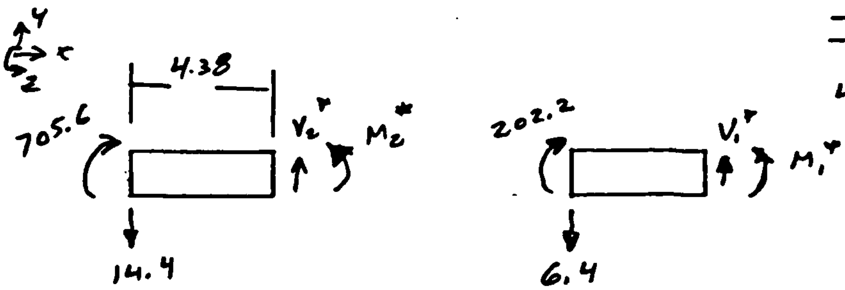
$$\sigma = \frac{345.4}{10.58} + \frac{544.1}{10.58} \quad \frac{5.73}{5.75} = 85.\ \text{KSI}$$

$$\sigma = \frac{202.2}{10.58} + \frac{705.9}{10.58} + \frac{2.9}{5.75} = 86.\ \text{KSI} \quad *$$

$$\tau = \frac{187.9}{2(5.75)^2(.25)} + \frac{3}{2}\,\frac{10.1}{3} = 16.\ \text{KSI}$$

Transfer Loads to edge of Joint





$$0 = -705.6 + M_2^* + 14.4(4.38) \qquad 0 = -202.2 + M_1^* + 6.4(4.38)$$

$$M_2^* = 642.5 \qquad M_1^* = 174.$$

$$\sigma = 77.7\ \text{KSI}$$

$$77.7\left(\frac{75}{80}\right) = 72.8$$

COLUMNS   CBeam 148 & 149   V = 0, 1, 0

6x6x 1/4 $I = 31.74$ $Z = 10.58$ $A = 5.75$
$A_s = 3.0$

M_1	M_2	V_1	V_2	P	T	grid	LC
∅, ∅							
192.4	-627.1	5.5	-11.8	3.63	132	126	
111.2	27.6	5.5	-11.8	3.63	132	143	A
151.8	745.6	4.5	-15.1	1.55	-48.6	129	
-97	90.9	4.5	-15.1	1.55	-48.6	145	
∅, 72							
179.5	65.9	3.6	12.0	3.44	160.6		
-22.1	.5	3.6	12.0	3.44	160.6		B
-103.3	-19.8	-.96	.75	5.2	-142.1		
-50.2	21.6	-.96	.75	5.2	-142.1		
22½, ∅							
45.4	-544.1	9.5	-10.	-5.73	108.	126	
178.8	11.4	9.5	-10.	-5.73	108.	143	C
202.2	705.9	6.4	14.4	2.9	-14.5	129	
-150.3	93.7	6.4	14.4	2.9	-14.5	145	
22½, 72							
406.4	163.6	10.1	3.7	-.2	187.9	126	
153.7	-40.1	10.1	3.7	-.2	187.9	143	I
88.2	-59.5	4.7	2.0	8.1	-80.6	129	
-173.9	54.0	4.7	2.0	8.1	-80.6	145	
SKID & BUMP							
47.3	46.6	1.4	.84	7.6	20.7		
-28.3	—	1.4	.84	7.6	20.7		E
-47.1	51.8	1.4	1.0	7.5	-24.7		
31.8	-4.1	1.4	1.0	7.5	-24.7		
4½ G's							
100.4	102.3	3.0	1.9	15.9	47.5		
-65.4	-4.0	3.0	1.9	15.9	47.5		
100.9	99.3	-3.0	1.9	1.6	-48.0		I
67.6	-4.4	-3.0	1.9	1.6	-48.0		

COLUMNS CBeam 148 & 149 V = 0,1,0

6x6x 1/4 $I = 31.74$ $Z = 10.58$ $A = 5.75$
$A_s = 3.0$

M_1	M_2	V_1	V_2	P	T	grid	LC
ø, ø							
192.4	-627.1	5.5	-11.8	3.63	132	126	
111.2	27.6	5.5	-11.8	3.63	132	143	A
151.8	745.6	4.5	-15.1	1.55	-48.6	129	
-97	90.9	4.5	-15.1	1.55	-48.6	145	
ø, 72							
179.5	65.9	3.6	12.0	3.44	160.6		
-22.1	.5	3.6	12.0	3.44	160.6		E
-103.3	-19.8	-.96	.75	5.2	-142.1		
-50.2	21.6	-.96	.75	5.2	-142.1		
22½, ø							
345.4	-544.1	9.5	-10.	-5.73	108.	126	
78.8	11.4	9.5	-10.	-5.73	108.	143	C
202.2	705.9	6.4	14.4	2.9	-14.5	129	
-150.3	93.7	6.4	14.4	2.9	-14.5	145	
22½, 72							
406.4	163.6	10.1	3.7	-.2	187.9	126	
153.7	-40.1	10.1	3.7	-.2	187.9	143	i
88.2	-59.5	4.7	2.0	8.1	-80.6	129	
-173.9	54.0	4.7	2.0	8.1	-80.6	145	
SKID & BUMP							
47.3	46.6	1.4	.84	7.6	20.7		
-28.3	—	1.4	.84	7.6	20.7		l
-47.1	51.8	1.4	1.0	7.5	±24.7		
31.8	-4.1	1.4	1.0	7.5	-24.7		
4½ G's							
100.4	102.3	3.0	1.9	15.9	47.5		
-65.4	-4.0	3.0	1.9	15.9	47.5		
-100.9	99.3	-3.0	1.9	1.6	-48.0		
67.6	-4.4	-3.0	1.9	1.6	-48.0		

Bottom Platform cBeam 117, 128 V = 1, 0, 0

$\frac{3}{4} \times 8$ $\frac{3}{8}$ Top $\frac{5}{16}$ Sid $I_1 = 96.6$ $Z_1 = 24.15$ $A = 10.37$

$I_2 = 99.5$ $Z_2 = 25.68$

Grid	M_1	M_2	V_1	V_2	P	T	
127	439.3	-55.6	-34.8	—	36.5	267.8	22½, 0
118	735.0	-52.9	-34.8	—	36.5	267.8	
118	1049.2	290.5	39.2	4.3	-11.8	-399.0	
128	716.2	254.0	39.2	4.3	-11.8	-399.0	
							22½, 72
127	398.1	152.0	-15.3	-32.4	70.4	-94.3	
118	528.3	427.7	-15.3	-32.4	70.4	-94.3	
118	944.7	884.2	33.6	32.8	6.3	-13.6	
128	659.4	604.9	33.6	32.8	6.3	-13.6	
							0, 0
127	679.0	-14.3	-41.8	-5.5	3.1	332.7	
118	1034.6	32.2	-41.8	-5.5	3.1	332.7	
[illegible]	1111.8	116.8	42.7	—	-8.8	-431.0	
[illegible]8	748.8	117.9	42.7	—	-8.8	-431.0	
							0, 72
127	532.6	240.9	-20.6	-31.0	52.5	-5.3	
118	707.5	504.5	-20.6	-31.0	52.5	-5.3	
118	956.6	777.6	35.5	34.1	14.2	14.3	
128	655.1	487.3	35.5	34.1	14.2	14.3	

$$\sigma = \frac{1049.2}{24.15} + \frac{290.5}{25.68} + \frac{11.8}{10.37} = 55.9$$

$$\sigma = \frac{944.7}{24.15} + \frac{884.2}{25.68} + \frac{6.3}{10.37} = 74.2$$

$\rightarrow 74.2\left(\frac{75}{80}\right) = 69.6$

$$\sigma = \frac{1111.8}{24.15} - \frac{116.8}{25.68} - \frac{42.7}{10.37} = 53.1$$

$$\tau = \frac{431}{2(7.688)(7.375)(.312)} + \frac{3(42.7)}{2(8)(2)(.375)} = 22.9$$

Bottom Plat Form   cBeams 117, 128   V = 1,0,0

Y 8   3/8 Top 5/16 Sid $I_1 = 96.6$ $Z_1 = 24.15$ $A = 10.37$

$I_2 = 99.5$ $Z_2 = 25.68$

Grid	M_1	M_2	V_1	V_2	P	T	
127	439.3	-55.6	-34.8	—	36.5	267.8	22½, 0
118	735.0	-52.9	-34.8	—	36.5	267.8	
118	1049.2	290.5	39.2	4.3	-11.8	-399.0	
128	716.2	254.0	39.2	4.3	-11.8	-399.0	
127	398.1	152.0	-15.3	-32.4	70.4	-94.3	22½, 72
118	528.3	427.7	-15.3	-32.4	70.4	-94.3	
118	944.7	884.2	33.6	32.8	6.3	-13.6	
128	659.4	604.9	33.6	32.8	6.3	-13.6	
127	679.0	-14.3	-41.8	-5.5	3.1	332.7	0, 0
118	1034.6	32.2	-41.8	-5.5	3.1	332.7	
	1111.8	116.8	42.7	—	-8.8	-431.0	
128	748.8	117.9	42.7	—	-8.8	-431.0	
127	532.6	240.9	-20.6	-31.0	52.5	-5.3	0, 72
118	707.5	504.5	-20.6	-31.0	52.5	-5.3	
118	956.6	777.6	35.5	34.1	14.2	14.3	
128	655.1	487.3	35.5	34.1	14.2	14.3	

Bottom Platform C Beam 110→115, 126, 119 → 125

σ x .312 A = 7.1 $I_1 = I_2 = 38.4$

$Z_1 = Z_2 = 12.8$

GRID	M_1	M_2	V_1	V_2	P	T	
ALL	168.3	276.1	25.4	1.6	35.9	378.	22, 0
ALL	177.4	227.6	25.2	23.8	32.5	173.5	22, 72
ALL	169.2	93.5	28.9	4.1	4.3	464.0	0, 0
ALL	178.6	111.1	28.2	23.0	16.7	108.5	0, 72

grid 116
126

$$\sigma = \frac{168.3 + 276.1}{12.8} + \frac{35.9}{7.1} = 39.8$$

$$\sigma = \frac{177.4 + 227.6}{12.8} + \frac{32.5}{7.1} = 36.7$$

$$\tau = \frac{464}{2(5.688)^2(.312)} + \frac{28.9}{(2)(3)(.312)}\frac{(3)}{(2)} = 46.1$$

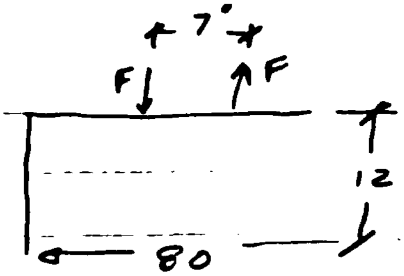
23 + 23

C Beam 116

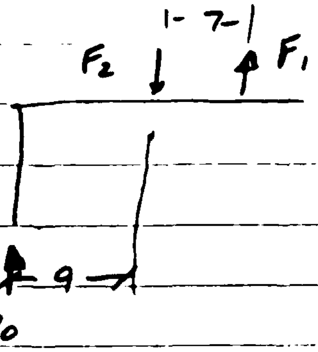
16, 117	156.6	-49.	-25.4	-	35.5	379.	22, 0
16, 117	260.	289.	-15.5	-23.6	68.5	-60.4	22, 72
16, 117	359.	-60.1	-28.9	-3.8	1.4	469.	0, 0
16, 117	361.	165.	-19.	-22.	50.	36.7	0, 72

$$\sigma = \frac{260 + 289}{12.8} + \frac{69}{7.1} = 43 + 9.7 = 52.6$$

$80 \times 12 =$

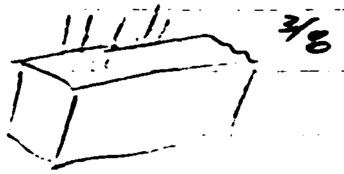


$F = 137/8 = 17/2 = 8.6$



$F_1 = 103. \quad F_2 = 183$

$F_2 = \frac{183}{8} = 22.9$ Kip



$\sigma = 80 = \frac{22.9}{3/8\, l}$

$l \doteq 3/4"$

$F_1/8 = 12.875$

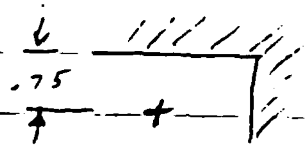
1/2" Bolt

Assume .42 dia $\quad A = .1385$

$\times$ 100 KSI

13.8 Kip

Need 9 Kip $\therefore$ OK



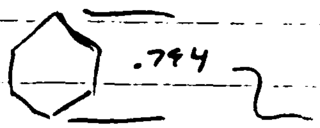
.4375 Bolt $\quad$ Assum .3602 dia

$A = .1019$

$\times$ 100 KSI

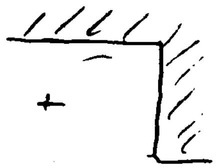
10.19 Kip $\quad$ OK

Need 9 Kip



+ 1/4 = 1.04

Assume 5/8

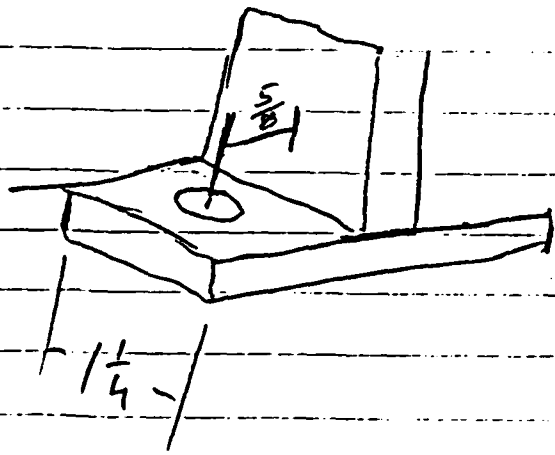


7/16 grade 8 $\quad$ Clamp Load <u>11.13 Kip</u>

Assume 9 Kip Bolt Load

$100\,KSI = \frac{9}{\pi r^2}$; $r = .34$ assume 3/8 Bolt

Assume Head = 3/4 Dia $\Longrightarrow$ 3/8 R + 1/4 clear

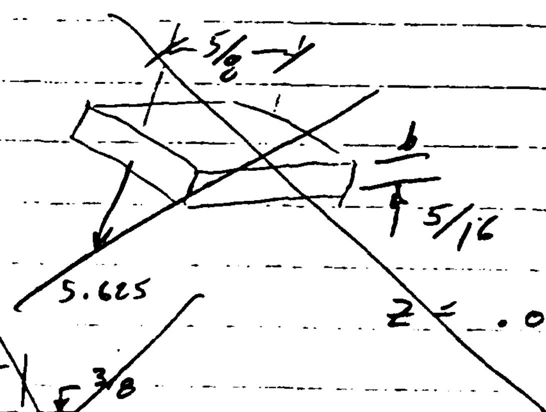


$M = \frac{5}{8}(9) = 5.625$

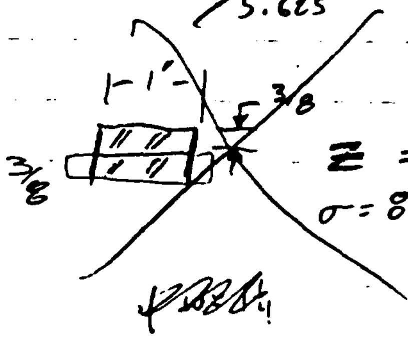
$\sigma = \frac{M}{Z} = 80 = \frac{5.625(6)}{1.25\,t^2}$

$t = \cancel{.24''} \rightarrow .58$ in

.312

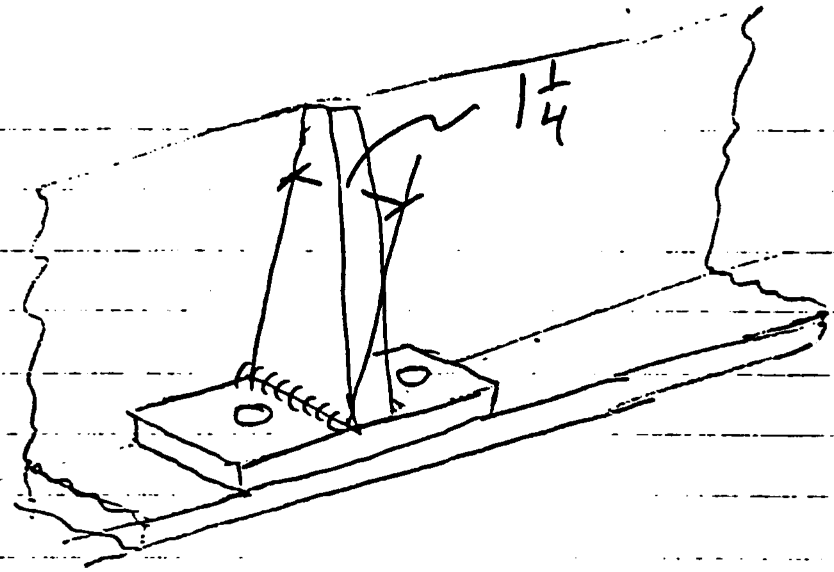


$Z = .0203$



$Z =$

$\sigma = 86$



assume E120xx class filler

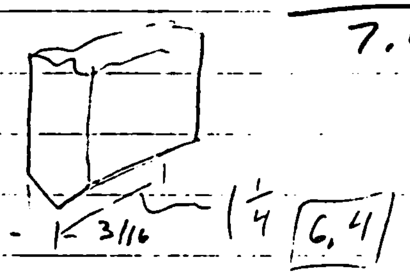
$l = 1\frac{1}{4}$ $\quad$ leg $= \frac{3}{4}\left(\frac{5}{16}\right) = .23$

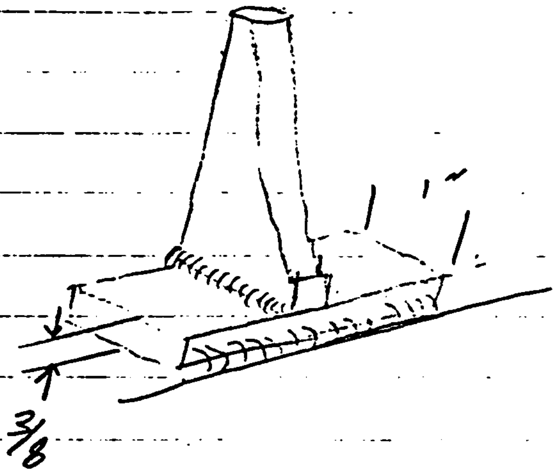
1"

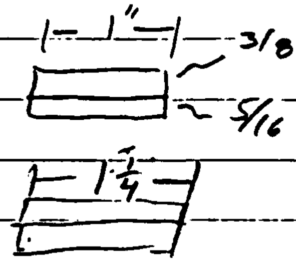
$120 \times 1" \times \cos 45 \times .3 \Rightarrow F_{ALLOW} = 25.4 \ \frac{Kip}{in}$

.23 $\quad f_w = 5.9$ Kip/in

$$\frac{\times 1.25}{7.46 \text{ Kip}}$$ Need 9 Kip





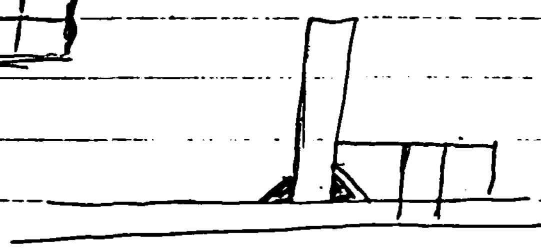


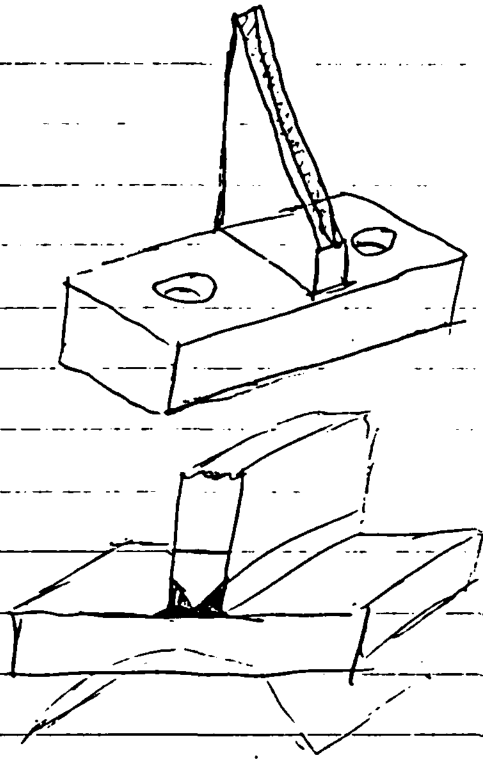
$Z = .0788$

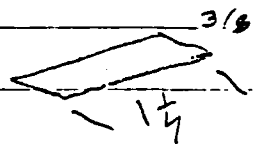
$\sigma = 71$

$\sigma = 57.1$

.28 $\quad S_A = 8.95$ Kip







$A = .4688$
$\underline{\times 120}$
56.2 Kip

$1'' \times \frac{5}{16} \times 120 = 37.5$ Kip

PART NUMBERS: 12585963, 12585964, Left and Right Hand Rails, machining
12586016-001, Rail Extrusion

DESCRIPTION: RAILS

The rail system includes the left and right rail and five collar sets as well as the clamp plates and nuts and bolts used in final assembly.

The extruded rail material of 7090 Al/20 v/o SiCp was chosen to provide an appropriate factor of safety and minimal deflection under the worst-case loading condition of a cook-off occurring between battery and load position. For this condition a factor of safety of 1.99 and maximum rail deflection of .17 inches is obtained. This stress and deflection analysis can be found in the following pages of this section.

STATUS:

Both the left and right rails (TDP, Dwgs. 12585963, 12585964 - machining, 12586016-001 - extrusion) are dimensioned and toleranced and are supported by a complete finite element analysis.

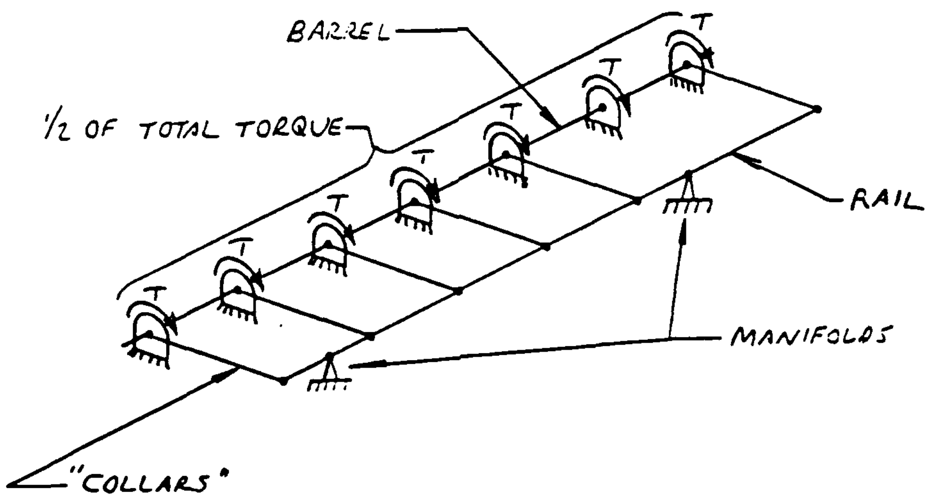
AUTHORS: Joe Fishbein, Joe Turek, Scott Dacko, Dave Warwick

RAILS

The rails attached to the barrel carry the loads generated by rifling torque to the manifolds in which the barrel/rail assembly travels. The worst case occurs during "cook-off", with the barrel part way between the loading and firing position. In this condition, both manifolds are positioned over the rail at points midspan between collars, resulting in high bending loads.

This condition was analyzed with a Finite Element model of the barrel, rail and collars. The barrel is supported along its length and is free in axial rotation only. "Rigid" arms, representing the collars, connect the barrel to the rail, and are attached to the rail in the three translation degrees of freedom only (no moments transferred). The rail is simply supported at the manifolds. One-half of the 48,000 ft-lb. rifling torque is distributed along the barrel.

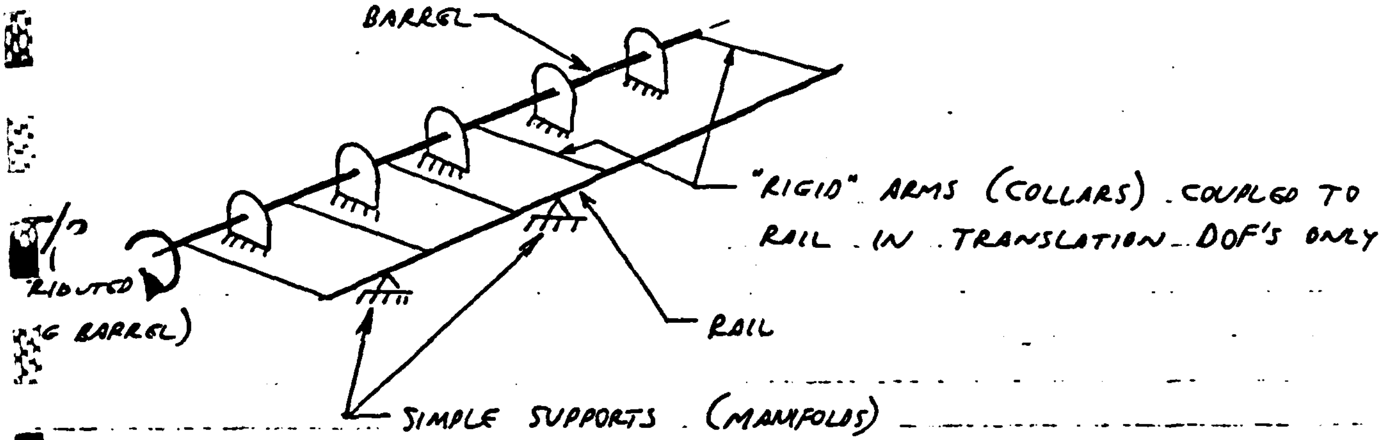
This model was run several times, to determine the worst-case positioning of the manifolds, and to try various rail geometries and materials. The final section, which resembles an "I" and is made from 7090-Al/20 v/o SiCp Aluminum Silicon Carbide (Yield strength = 95,000 PSI), has a maximum bending stress of 47,695 PSI (FS=1.99). At the collar attachment, where some web material is removed, maximum bending stress = 30,835 PSI (FS=3.08). Maximum deflection is 0.170 in.



BARREL/RAIL MODEL

RAILS

1. RIFLING TORQUE – 48,000 FT-LB., COOK-OFF WITH BARREL/RAIL ASSEMBLY IN INTERMEDIATE POSITION. ACTUAL LOADING ON RAIL DETERMINED BY MODEL OF BARREL/RAIL SYSTEM:

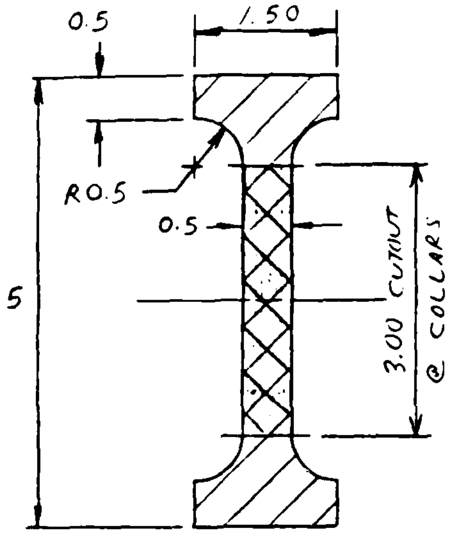


FMC Northern Ordnance Division
Minneapolis

APPLIED MECHANICS

Subject	Analyst	
LTHD	JMF	
	Project Number	
	EC No.	Date 1-22-87

LATEST SECTION (AS OF 1/~~27~~ 28/87, ~~[illegible]~~ — PER D. WARWICK)



SECTION PROPERTIES: (VIA CD2000):

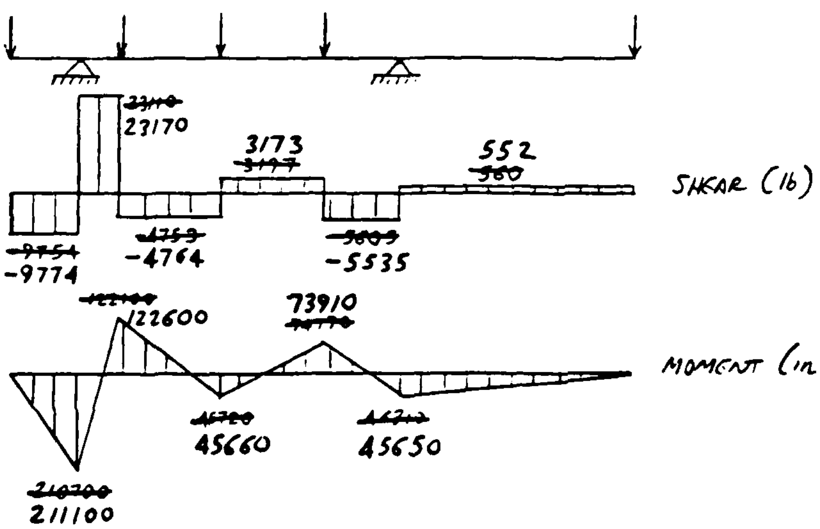
- $A = 3.7165\ in$
- $I_Z = 11.0651\ in^4$
- $I_Y = 0.3533\ in^4$

- $J \approx (5)(.5)^3/3 = .2083\ in^4$

MAT'L: ALUMINUM 7090 w/ ~~30%~~ 20% SiC
$E = \cancel{18.5 \times 10^6\ psi}\ 15 \times 10^6\ psi$
$\rho = .104\ lb/in$
$\alpha = 8.0 \times 10^{-6}\ {}^\circ F^{-1}$ } ASSUMED
$\nu = .23$
$F_y = \cancel{102\ KSI}\ 95\ KSI$

AREAS WITH CUTOUT

$$A = 3.7165\ in^2 - (.50)(3.00) = 2.2165\ in^2$$
$$I_Z = 11.0651\ in^4 - (.5)(3)^3/12 = 9.9401\ in^4$$
$$I_Y = .3533\ in^4 - (3)(.5)^3/12 = .3221\ in^4$$



$\Delta max = \cancel{.138}\ in$
$.170\ in$

Sheet ___ Of ___

DA-649Oct85

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Minneapolis

APPLIED MECHANICS

Subject	Analyst	
LTHD	Project Number	
	EC No.	Date 1-27

STRESS @ MANIFOLD

$M_{max} = 211{,}100$ in-lb

$\sigma_b = \dfrac{(211100)(2.5 \text{ in})}{11.0651 \text{ in}^4} = 47695$ psi $\quad FS = \dfrac{95000}{47695} = 1.99$

$\tau = \dfrac{23170 \text{ lb}}{(5.0)(.5)} = 9268$ psi $\quad FS = \dfrac{(.58)(95000)}{9268} = 5.95$

STRESS @ COLLAR

$M_{max} = 122{,}600$ in-lb

$\sigma_b = \dfrac{(122600)(2.5)}{(9.9401)} = 30835$ psi $\quad FS = \dfrac{95000}{30835} = 3.08$

$\tau = \dfrac{23110 \text{ lb}}{(2)(.5)} = 23110$ psi $\quad FS = \dfrac{(.58)(95000)}{23110} = 2.38$

BEARING: $A = (.5 \text{ in})(4.00 \text{ in}) = 2.00 \text{ in}^2$

MAX COLLAR LOAD $= 23170$ lb $+ 4764$ lb $= 27934$ lb

$\sigma_{brg} = \dfrac{27934 \text{ lb}}{2.00 \text{ in}^2} = 13967$ psi $\quad FS = \dfrac{95000}{13967} = 6.80$

MINIMUM FS = 1.99

MAX Δ = .170 in

DA-649Oct85

```
  AAAAAA     AAAAAA      666666     5555555555    000000      888888      222222
  AAAAAA     AAAAAA      666666     5555555555    000000      888888      222222
AA        AA AA        AA 66        55          00        00 88        88 22        22
AA        AA AA        AA 66        55          00        00 88        88 22        22
AA        AA AA        AA 66        555555      00      0000 88        88           22
AA        AA AA        AA 66        555555      00      0000 88        88           22
AA        AA AA        AA 66666666        55    00   00   00   888888           22
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AA        AA AA        AA   666666    555555    000000      888888    2222222222
```

FMC CORPORATION S/N:800484

J o b I n f o r m a t i o n

Project : LTHD

Client : ____________________

Job Name : Barrel Guide Rail

Remarks : Intermediate Cook-off
Al-7090 w/20% SiC

Engineer : ______________/________
J. Fishbein

Chk'd by : ______________/________

Appr'd by : ______________/________

Comments : ________________________

____

9

```
================ I M A G E S  3 D ==============
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Interactive Microcomputer Analysis & Graphics of Engineering Systems

IMAGES-3D  Version 1.3  03/01/86

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=================================================
```

CHECK GEOMETRY Version 1.3 of 01/86

[illegible] barrel and rail under rifling torque load

MATERIAL PROPERTIES

Material No.	Modulus of Elasticity	Weight Density	Coeff of Thermal Exp.	Poisson's Ratio	Shear Web Modulus
1	1.50000E+07	1.04000E-01	6.00000E-06	2.70E-01	0.00000E+00
2	2.90000E+07	2.83000E-01	6.60000E-06	3.00E-01	0.00000E+00

NODE COORDINATES

Node	X-Coord.	Y-Coord.	Z-Coord.
1	1.37880E+01	1.00000E+01	0.00000E+00
2	1.37880E+01	0.00000E+00	0.00000E+00
3	2.09580E+01	0.00000E+00	0.00000E+00
4	2.81680E+01	0.00000E+00	0.00000E+00
5	3.57880E+01	0.00000E+00	0.00000E+00
6	4.25680E+01	0.00000E+00	0.00000E+00
7	4.97880E+01	0.00000E+00	0.00000E+00
8	5.66160E+01	0.00000E+00	0.00000E+00
9	6.74440E+01	0.00000E+00	0.00000E+00
10	7.61720E+01	0.00000E+00	0.00000E+00
11	8.51000E+01	0.00000E+00	0.00000E+00
12	9.45220E+01	0.00000E+00	0.00000E+00
13	1.03944E+02	0.00000E+00	0.00000E+00
14	1.13366E+02	0.00000E+00	0.00000E+00
15	1.22788E+02	0.00000E+00	0.00000E+00
16	1.29988E+02	0.00000E+00	0.00000E+00
17	1.37188E+02	0.00000E+00	0.00000E+00
18	1.44388E+02	0.00000E+00	0.00000E+00
19	1.51588E+02	0.00000E+00	0.00000E+00
20	1.58788E+02	0.00000E+00	0.00000E+00
21	1.66378E+02	0.00000E+00	0.00000E+00
22	1.73968E+02	0.00000E+00	0.00000E+00
23	1.81559E+02	0.00000E+00	0.00000E+00
24	1.89149E+02	0.00000E+00	0.00000E+00
25	1.96739E+02	0.00000E+00	0.00000E+00
26	2.04329E+02	0.00000E+00	0.00000E+00
27	2.11920E+02	0.00000E+00	0.00000E+00

==== ========== I M A G E S 3 D ================
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CHECK GEOMETRY Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

Node	X-Coord.	Y-Coord.	Z-Coord.
28	2.19510E+02	0.00000E+00	0.00000E+00
29	2.27100E+02	0.00000E+00	0.00000E+00
30	1.37800E+01	0.00000E+00	-7.37500E+00
31	4.97630E+01	0.00000E+00	-7.37500E+00
32	8.51000E+01	0.00000E+00	-7.37500E+00
33	1.22799E+02	0.00000E+00	-7.37500E+00
34	1.57559E+02	0.00000E+00	-7.37500E+00
35	1.92329E+02	0.00000E+00	-7.37500E+00
36	2.27100E+02	0.00000E+00	-7.37500E+00

BEAM PROPERTIES

Multiplier = 1 (For AISC database properties only)

Prop No	X-Section Area	Moment of Inertia Iy	/ Iz	Torsional Const.- J
1	3.717E+00	3.533E-01	1.107E+01	2.083E-01
2	6.364E+01	6.186E+02	6.186E+02	1.237E+03
3	5.728E+01	5.276E+02	5.276E+02	1.055E+03
4	4.434E+01	3.627E+02	3.627E+02	7.253E+02
5	3.517E+01	2.620E+02	2.620E+02	5.241E+02
6	2.999E+01	2.111E+02	2.111E+02	4.221E+02
7	2.502E+01	1.662E+02	1.662E+02	3.325E+02
8	1.000E+03	1.000E+05	1.000E+05	1.000E+05

Prop No	Max. Fiber Dist Cy	/ Cz	Shear Shape Fact SSFy	/ SSFz	Ctors
1	2.50E+00	7.50E-01	1.18E+00	1.18E+00	1.00E+00
2	5.44E+00	5.44E+00	1.89E+00	1.89E+00	1.00E+00
3	5.25E+00	5.25E+00	1.89E+00	1.89E+00	1.00E+00
4	4.84E+00	4.84E+00	1.89E+00	1.89E+00	1.00E+00
5	4.53E+00	4.53E+00	1.89E+00	1.89E+00	1.00E+00
6	4.74E+00	4.74E+00	1.89E+00	1.89E+00	1.00E+00
7	4.16E+00	4.16E+00	1.89E+00	1.89E+00	1.00E+00
8	1.00E-02	1.00E-02	0.00E+00	0.00E+00	1.00E+00

CHECK GEOMETRY Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

BEAM CONNECTIVITY

Beam No	Nodes From/	To/	Ref	Prop No	Mat No	Pincodes I / J	Length	Y Dir Cosines X	Y	Z	Beam Type
1	2	3	1	1	1		7.200E+00	0.00	1.00	0.00	Beam
2	3	4	1	1	1		7.200E+00	0.00	1.00	0.00	Beam
3	4	5	1	1	1		7.200E+00	0.00	1.00	0.00	Beam
4	5	6	1	1	1		7.200E+00	0.00	1.00	0.00	Beam
5	6	7	1	1	1		7.200E+00	0.00	1.00	0.00	Beam
6	7	8	1	1	1		8.828E+00	0.00	1.00	0.00	Beam
7	8	9	1	1	1		8.828E+00	0.00	1.00	0.00	Beam
8	9	10	1	1	1		8.828E+00	0.00	1.00	0.00	Beam
9	10	11	1	1	1		8.828E+00	0.00	1.00	0.00	Beam
10	11	12	1	1	1		9.422E+00	0.00	1.00	0.00	Beam
11	12	13	1	1	1		9.422E+00	0.00	1.00	0.00	Beam
12	13	14	1	1	1		9.422E+00	0.00	1.00	0.00	Beam
13	14	15	1	1	1		9.422E+00	0.00	1.00	0.00	Beam
14	15	16	1	1	1		7.200E+00	0.00	1.00	0.00	Beam
15	16	17	1	1	1		7.200E+00	0.00	1.00	0.00	Beam
16	17	18	1	1	1		7.200E+00	0.00	1.00	0.00	Beam
17	18	19	1	1	1		7.200E+00	0.00	1.00	0.00	Beam
18	19	20	1	1	1		7.200E+00	0.00	1.00	0.00	Beam
19	20	21	1	1	1		7.590E+00	0.00	1.00	0.00	Beam
20	21	22	1	1	1		7.590E+00	0.00	1.00	0.00	Beam
21	22	23	1	1	1		7.591E+00	0.00	1.00	0.00	Beam
22	23	24	1	1	1		7.590E+00	0.00	1.00	0.00	Beam
23	24	25	1	1	1		7.590E+00	0.00	1.00	0.00	Beam
24	25	26	1	1	1		7.590E+00	0.00	1.00	0.00	Beam
25	26	27	1	1	1		7.591E+00	0.00	1.00	0.00	Beam
26	27	28	1	1	1		7.590E+00	0.00	1.00	0.00	Beam
27	28	29	1	1	1		7.590E+00	0.00	1.00	0.00	Beam
28	30	31	2	2	2		3.600E+01	0.00	0.00	1.00	Beam
29	31	32	2	3	2		3.531E+01	0.00	0.00	1.00	Beam
30	32	33	2	4	2		3.769E+01	0.00	0.00	1.00	Beam
31	33	34	2	5	2		3.477E+01	0.00	0.00	1.00	Beam
32	34	35	2	6	2		3.477E+01	0.00	0.00	1.00	Beam
33	35	36	2	7	2		3.477E+01	0.00	0.00	1.00	Beam
34	30	2	29	8	2	456	7.375E+00	1.00	0.00	0.00	Beam
35	31	7	29	8	2	456	7.375E+00	1.00	0.00	0.00	Beam
36	32	11	29	8	2	456	7.375E+00	1.00	0.00	0.00	Beam
37	33	15	29	8	2	456	7.375E+00	1.00	0.00	0.00	Beam
38	36	29	2	8	2	456	7.375E+00	-1.00	0.00	0.00	Beam

CHECK GEOMETRY Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

NODAL CONNECTIVITY

*** WARNING - Node 1 not connected to any element ***

RESTRAINTS

Node No	Restraint Directions
1	X Y Z RX RY RZ
5	- Y - RX - -
18	- Y - RX - -
30	X Y Z - RY RZ
31	X Y Z - RY RZ
32	X Y Z - RY RZ
33	X Y Z - RY RZ
34	X Y Z - RY RZ
35	X Y Z - RY RZ
36	X Y Z - RY RZ

RENUMBER NODES Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

Node Renumbering Cross Reference List

Was	Is	Was	Is	Was	Is
1	36	2	4	3	2
4	1	5	3	6	5
7	7	8	9	9	11
10	14	11	13	12	17
13	21	14	19	15	16
16	20	17	23	18	25
19	27	20	29	21	31
22	33	23	35	24	34
25	32	26	30	27	28
28	26	29	24	30	6
31	8	32	10	33	12
34	15	35	18	36	22

Original Nodal Band 29
Final Nodal band 5

ASSEMBLE STIFFNESS MATRIX Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

STIFFNESS ASSEMBLY SUMMARY

Number of Node Points.................	36
Number of Truss and Beam Elements.....	38
Number of Plate Elements..............	0
Number of Spring Elements.............	0
Number of Nodes with Restraints.......	10
Number of Blocks in the Matrix........	1

BLOCK NUMBER 1

FORM Matrix
PACK Matrix
Size = 16608 Bytes
TRIANGULARIZE Matrix

Number of terms in the matrix.	2076
Largest column................	24
Minimum Diagonal Stiffness =	.1465925D+06
Maximum Diagonal Stiffness =	.1180378D+13

ASSEMBLE STIFFNESS MATRIX Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

C R O S S R E F E R E N C E L I S T

Is Node Verus Internal Equation Number

Is Node	TRANSLATION Eqn.	TRANSLATION Eqn.	TRANSLATION Eqn.	ROTATION Eqn.	ROTATION Eqn.	ROTATION Eqn.
1	1	2	3	4	5	6
2	7	8	9	10	11	12
3	13		14		15	16
4	17	18	19	20	21	22
5	23	24	25	26	27	28
6				29		
7	30	31	32	33	34	35
8				36		
9	37	38	39	40	41	42
10				43		
11	44	45	46	47	48	49
12				50		
13	51	52	53	54	55	56
14	57	58	59	60	61	62
15				63		
16	64	65	66	67	68	69
17	70	71	72	73	74	75
18				76		
19	77	78	79	80	81	82
20	83	84	85	86	87	88
21	89	90	91	92	93	94
22				95		
23	96	97	98	99	100	101
24	102	103	104	105	106	107
25	108		109		110	111
26	112	113	114	115	116	117
27	118	119	120	121	122	123
28	124	125	126	127	128	129
29	130	131	132	133	134	135
30	136	137	138	139	140	141
31	142	143	144	145	146	147
32	148	149	150	151	152	153
33	154	155	156	157	158	159
34	160	161	162	163	164	165
35	166	167	168	169	170	171

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SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

L O A D C A S E 1

Cool-off in load position

CONCENTRATED LOADS

Node	Fx	Fy	Fz	Mx	My	Mz
30	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00
31	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00
32	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00
33	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00
34	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00
35	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00
36	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00

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SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

L O A D C A S E 1

Cook-off in load position

APPLIED LOAD VECTOR

Node	Fx	Fy	Fz	Mx	My	Mz
30	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00
31	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00
32	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00
33	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00
34	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00
35	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00
36	.0000E+00	.0000E+00	.0000E+00	.4112E+05	.0000E+00	.0000E+00

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SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

L O A D C A S E 1
Cook-off in load position

DISPLACEMENTS

	Translations			/	Rotations		
Node	X	Y	Z	/	X	Y	Z
1	.0000E+00	.0000E+00	.0000E+00	/	.0000E+00	.0000E+00	.0000E+00
2	.0000E+00	-.1310E+00	.0000E+00	/	-.3188E-10	.0000E+00	.1014E-01
3	.0000E+00	-.5805E-01	.0000E+00	/	-.2125E-10	.0000E+00	.8610E-02
4	.0000E+00	-.7045E-02	.0000E+00	/	-.1063E-10	.0000E+00	.4031E-02
5	.0000E+00	.0000E+00	.0000E+00	/	.0000E+00	.0000E+00	-.3601E-02
6	.0000E+00	-.5890E-01	.0000E+00	/	-.1750E-10	.0000E+00	-.9140E-02
7	.0000E+00	-.1316E+00	.0000E+00	/	-.3500E-10	.0000E+00	-.7443E-02
8	.0000E+00	-.1697E+00	.0000E+00	/	-.4337E-10	.0000E+00	-.2043E-02
9	.0000E+00	-.1699E+00	.0000E+00	/	-.5173E-10	.0000E+00	.1120E-02
10	.0000E+00	-.1521E+00	.0000E+00	/	-.6010E-10	.0000E+00	.2047E-02
11	.0000E+00	-.1360E+00	.0000E+00	/	-.6847E-10	.0000E+00	.7366E-03
12	.0000E+00	-.1401E+00	.0000E+00	/	-.6297E-10	.0000E+00	-.1007E-02
13	.0000E+00	-.1527E+00	.0000E+00	/	-.5748E-10	.0000E+00	-.1054E-02
14	.0000E+00	-.1578E+00	.0000E+00	/	-.5198E-10	.0000E+00	.5964E-03
15	.0000E+00	-.1393E+00	.0000E+00	/	-.4648E-10	.0000E+00	.3943E-02
16	.0000E+00	-.9933E-01	.0000E+00	/	-.3099E-10	.0000E+00	.6285E-02
17	.0000E+00	-.4876E-01	.0000E+00	/	-.1549E-10	.0000E+00	.6898E-02
18	.0000E+00	.0000E+00	.0000E+00	/	.0000E+00	.0000E+00	.5782E-02
19	.0000E+00	.3450E-01	.0000E+00	/	-.1227E-10	.0000E+00	.3888E-02
20	.0000E+00	.5599E-01	.0000E+00	/	-.2454E-10	.0000E+00	.2166E-02
21	.0000E+00	.6591E-01	.0000E+00	/	-.3748E-10	.0000E+00	.5381E-03
22	.0000E+00	.6420E-01	.0000E+00	/	-.5041E-10	.0000E+00	-.8986E-03
23	.0000E+00	.5232E-01	.0000E+00	/	-.6335E-10	.0000E+00	-.2144E-02
24	.0000E+00	.3171E-01	.0000E+00	/	-.7629E-10	.0000E+00	-.3198E-02
25	.0000E+00	.3826E-02	.0000E+00	/	-.8922E-10	.0000E+00	-.4060E-02
26	.0000E+00	-.2987E-01	.0000E+00	/	-.1022E-09	.0000E+00	-.4730E-02
27	.0000E+00	-.6793E-01	.0000E+00	/	-.1151E-09	.0000E+00	-.5209E-02
28	.0000E+00	-.1089E+00	.0000E+00	/	-.1280E-09	.0000E+00	-.5496E-02
29	.0000E+00	-.1513E+00	.0000E+00	/	-.1410E-09	.0000E+00	-.5592E-02
30	.0000E+00	.0000E+00	.0000E+00	/	.1777E-01	.0000E+00	.0000E+00
31	.0000E+00	.0000E+00	.0000E+00	/	.1785E-01	.0000E+00	.0000E+00
32	.0000E+00	.0000E+00	.0000E+00	/	.1844E-01	.0000E+00	.0000E+00
33	.0000E+00	.0000E+00	.0000E+00	/	.1888E-01	.0000E+00	.0000E+00
34	.0000E+00	.0000E+00	.0000E+00	/	.1959E-01	.0000E+00	.0000E+00
35	.0000E+00	.0000E+00	.0000E+00	/	.2017E-01	.0000E+00	.0000E+00
36	.0000E+00	.0000E+00	.0000E+00	/	.2052E-01	.0000E+00	.0000E+00

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

Load Case 1:Cook-off in load position

BEAM LOADS AND/OR STRESSES

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
BEAM NO. 1							
LLoads	2	.0000E+00	-.9774E+04	.0000E+00	-.1874E-05	.0000E+00	-.4646E-08
LLoads	3	.0000E+00	.9774E+04	.0000E+00	.1874E-05	.0000E+00	-.7037E+05
Stress	2	.0000E+00	-.3103E+04	.0000E+00	.8999E-05	.1050E-08	.0000E+00
Stress	3	.0000E+00	-.3103E+04	.0000E+00	.8999E-05	-.1590E+05	.0000E+00
BEAM NO. 2							
LLoads	3	.0000E+00	-.9774E+04	.0000E+00	-.1874E-05	.0000E+00	.7037E+05
LLoads	4	.0000E+00	.9774E+04	.0000E+00	.1874E-05	.0000E+00	-.1407E+06
Stress	3	.0000E+00	-.3103E+04	.0000E+00	.8999E-05	-.1590E+05	.0000E+00
Stress	4	.0000E+00	-.3103E+04	.0000E+00	.8999E-05	-.3180E+05	.0000E+00
BEAM NO. 3							
LLoads	4	.0000E+00	-.9774E+04	.0000E+00	-.1874E-05	.0000E+00	.1407E+06
LLoads	5	.0000E+00	.9774E+04	.0000E+00	.1874E-05	.0000E+00	-.2111E+06
Stress	4	.0000E+00	-.3103E+04	.0000E+00	.8999E-05	-.3180E+05	.0000E+00
Stress	5	.0000E+00	-.3103E+04	.0000E+00	.8999E-05	-.4770E+05	.0000E+00
BEAM NO. 4							
LLoads	5	.0000E+00	.2317E+05	.0000E+00	.3087E-05	.0000E+00	.2111E+06
LLoads	6	.0000E+00	-.2317E+05	.0000E+00	-.3087E-05	.0000E+00	-.4428E+05
Stress	5	.0000E+00	.7357E+04	.0000E+00	-.1482E-04	-.4770E+05	.0000E+00
Stress	6	.0000E+00	.7357E+04	.0000E+00	-.1482E-04	-.1001E+05	.0000E+00
BEAM NO. 5							
LLoads	6	.0000E+00	.2317E+05	.0000E+00	.3087E-05	.0000E+00	.4428E+05
LLoads	7	.0000E+00	-.2317E+05	.0000E+00	-.3087E-05	.0000E+00	.1226E+06
Stress	6	.0000E+00	.7357E+04	.0000E+00	-.1482E-04	-.1001E+05	.0000E+00
Stress	7	.0000E+00	.7357E+04	.0000E+00	-.1482E-04	.2769E+05	.0000E+00
BEAM NO. 6							
LLoads	7	.0000E+00	-.4764E+04	.0000E+00	.1204E-05	.0000E+00	-.1226E+06
LLoads	8	.0000E+00	.4764E+04	.0000E+00	-.1204E-05	.0000E+00	.8050E+05
Stress	7	.0000E+00	-.1512E+04	.0000E+00	-.5780E-05	.2769E+05	.0000E+00
Stress	8	.0000E+00	-.1512E+04	.0000E+00	-.5780E-05	.1819E+05	.0000E+00
BEAM NO. 7							
LLoads	8	.0000E+00	-.4764E+04	.0000E+00	.1204E-05	.0000E+00	-.8050E+05
LLoads	9	.0000E+00	.4764E+04	.0000E+00	-.1204E-05	.0000E+00	.3845E+05
Stress	8	.0000E+00	-.1512E+04	.0000E+00	-.5780E-05	.1819E+05	.0000E+00
Stress	9	.0000E+00	-.1512E+04	.0000E+00	-.5780E-05	.8686E+04	.0000E+00
BEAM NO. 8							
LLoads	9	.0000E+00	-.4764E+04	.0000E+00	.1204E-05	.0000E+00	-.3845E+05
LLoads	10	.0000E+00	.4764E+04	.0000E+00	-.1204E-05	.0000E+00	-.3608E+04
Stress	9	.0000E+00	-.1512E+04	.0000E+00	-.5780E-05	.8686E+04	.0000E+00
Stress	10	.0000E+00	-.1512E+04	.0000E+00	-.5780E-05	-.8151E+03	.0000E+00

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

Load Case 1:Cook-off in load position

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
				BEAM NO. 9			
LLoads	10	.0000E+00	-.4764E+04	.0000E+00	.1204E-05	.0000E+00	.3608E+04
LLoads	11	.0000E+00	.4764E+04	.0000E+00	-.1204E-05	.0000E+00	-.4566E+05
Stress	10	.0000E+00	-.1512E+04	.0000E+00	-.5780E-05	-.8151E+03	.0000E+00
Stress	11	.0000E+00	-.1512E+04	.0000E+00	-.5780E-05	-.1032E+05	.0000E+00
				BEAM NO. 10			
LLoads	11	.0000E+00	.3173E+04	.0000E+00	-.7410E-06	.0000E+00	.4566E+05
LLoads	12	.0000E+00	-.3173E+04	.0000E+00	.7410E-06	.0000E+00	-.1577E+05
Stress	11	.0000E+00	.1007E+04	.0000E+00	.3557E-05	-.1032E+05	.0000E+00
Stress	12	.0000E+00	.1007E+04	.0000E+00	.3557E-05	-.3563E+04	.0000E+00
				BEAM NO. 11			
LLoads	12	.0000E+00	.3173E+04	.0000E+00	-.7410E-06	.0000E+00	.1577E+05
LLoads	13	.0000E+00	-.3173E+04	.0000E+00	.7410E-06	.0000E+00	.1412E+05
Stress	12	.0000E+00	.1007E+04	.0000E+00	.3557E-05	-.3563E+04	.0000E+00
Stress	13	.0000E+00	.1007E+04	.0000E+00	.3557E-05	.3191E+04	.0000E+00
				BEAM NO. 12			
LLoads	13	.0000E+00	.3173E+04	.0000E+00	-.7410E-06	.0000E+00	-.1412E+05
LLoads	14	.0000E+00	-.3173E+04	.0000E+00	.7410E-06	.0000E+00	.4401E+05
Stress	13	.0000E+00	.1007E+04	.0000E+00	.3557E-05	.3191E+04	.0000E+00
Stress	14	.0000E+00	.1007E+04	.0000E+00	.3557E-05	.9944E+04	.0000E+00
				BEAM NO. 13			
LLoads	14	.0000E+00	.3173E+04	.0000E+00	-.7410E-06	.0000E+00	-.4401E+05
LLoads	15	.0000E+00	-.3173E+04	.0000E+00	.7410E-06	.0000E+00	.7391E+05
Stress	14	.0000E+00	.1007E+04	.0000E+00	.3557E-05	.9944E+04	.0000E+00
Stress	15	.0000E+00	.1007E+04	.0000E+00	.3557E-05	.1670E+05	.0000E+00
				BEAM NO. 14			
LLoads	15	.0000E+00	-.5535E+04	.0000E+00	-.2733E-05	.0000E+00	-.7391E+05
LLoads	16	.0000E+00	.5535E+04	.0000E+00	.2733E-05	.0000E+00	.3405E+05
Stress	15	.0000E+00	-.1757E+04	.0000E+00	.1312E-04	.1670E+05	.0000E+00
Stress	16	.0000E+00	-.1757E+04	.0000E+00	.1312E-04	.7694E+04	.0000E+00
				BEAM NO. 15			
LLoads	16	.0000E+00	-.5535E+04	.0000E+00	-.2733E-05	.0000E+00	-.3405E+05
LLoads	17	.0000E+00	.5535E+04	.0000E+00	.2733E-05	.0000E+00	-.5797E+04
Stress	16	.0000E+00	-.1757E+04	.0000E+00	.1312E-04	.7694E+04	.0000E+00
Stress	17	.0000E+00	-.1757E+04	.0000E+00	.1312E-04	-.1310E+04	.0000E+00
				BEAM NO. 16			
LLoads	17	.0000E+00	-.5535E+04	.0000E+00	-.2733E-05	.0000E+00	.5797E+04
LLoads	18	.0000E+00	.5535E+04	.0000E+00	.2733E-05	.0000E+00	-.4565E+05
Stress	17	.0000E+00	-.1757E+04	.0000E+00	.1312E-04	-.1310E+04	.0000E+00
Stress	18	.0000E+00	-.1757E+04	.0000E+00	.1312E-04	-.1031E+05	.0000E+00
				BEAM NO. 17			
LLoads	18	.0000E+00	.5519E+03	.0000E+00	.2165E-05	.0000E+00	.4565E+05

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

Load Case 1:Cool-off in load position

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
LLoads	19	.0000E+00	-.5519E+03	.0000E+00	-.2165E-05	.0000E+00	-.4168E+05
Stress	18	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.1031E+05	.0000E+00
Stress	19	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.9416E+04	.0000E+00
			BEAM NO. 18				
LLoads	19	.0000E+00	.5519E+03	.0000E+00	.2165E-05	.0000E+00	.4168E+05
LLoads	20	.0000E+00	-.5519E+03	.0000E+00	-.2165E-05	.0000E+00	-.3770E+05
Stress	19	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.9416E+04	.0000E+00
Stress	20	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.8518E+04	.0000E+00
			BEAM NO. 19				
LLoads	20	.0000E+00	.5519E+03	.0000E+00	.2165E-05	.0000E+00	.3770E+05
LLoads	21	.0000E+00	-.5519E+03	.0000E+00	-.2165E-05	.0000E+00	-.3351E+05
Stress	20	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.8518E+04	.0000E+00
Stress	21	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.7572E+04	.0000E+00
			BEAM NO. 20				
LLoads	21	.0000E+00	.5519E+03	.0000E+00	.2165E-05	.0000E+00	.3351E+05
LLoads	22	.0000E+00	-.5519E+03	.0000E+00	-.2165E-05	.0000E+00	-.2932E+05
Stress	21	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.7572E+04	.0000E+00
Stress	22	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.6625E+04	.0000E+00
			BEAM NO. 21				
LLoads	22	.0000E+00	.5519E+03	.0000E+00	.2165E-05	.0000E+00	.2932E+05
LLoads	23	.0000E+00	-.5519E+03	.0000E+00	-.2165E-05	.0000E+00	-.2513E+05
Stress	22	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.6625E+04	.0000E+00
Stress	23	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.5679E+04	.0000E+00
			BEAM NO. 22				
LLoads	23	.0000E+00	.5519E+03	.0000E+00	.2165E-05	.0000E+00	.2513E+05
LLoads	24	.0000E+00	-.5519E+03	.0000E+00	-.2165E-05	.0000E+00	-.2095E+05
Stress	23	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.5679E+04	.0000E+00
Stress	24	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.4732E+04	.0000E+00
			BEAM NO. 23				
LLoads	24	.0000E+00	.5519E+03	.0000E+00	.2165E-05	.0000E+00	.2095E+05
LLoads	25	.0000E+00	-.5519E+03	.0000E+00	-.2165E-05	.0000E+00	-.1676E+05
Stress	24	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.4732E+04	.0000E+00
Stress	25	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.3786E+04	.0000E+00
			BEAM NO. 24				
LLoads	25	.0000E+00	.5519E+03	.0000E+00	.2165E-05	.0000E+00	.1676E+05
LLoads	26	.0000E+00	-.5519E+03	.0000E+00	-.2165E-05	.0000E+00	-.1257E+05
Stress	25	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.3786E+04	.0000E+00
Stress	26	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.2839E+04	.0000E+00
			BEAM NO. 25				
LLoads	26	.0000E+00	.5519E+03	.0000E+00	.2165E-05	.0000E+00	.1257E+05
LLoads	27	.0000E+00	-.5519E+03	.0000E+00	-.2165E-05	.0000E+00	-.8378E+04
Stress	26	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.2839E+04	.0000E+00

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

Load Case 1:Cool-off in load position

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
Stress	27	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.1893E+04	.0000E+00
BEAM NO. 26							
LLoads	27	.0000E+00	.5519E+03	.0000E+00	.2165E-05	.0000E+00	.8378E+04
LLoads	28	.0000E+00	-.5519E+03	.0000E+00	-.2165E-05	.0000E+00	-.4189E+04
Stress	27	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.1893E+04	.0000E+00
Stress	28	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.9464E+03	.0000E+00
BEAM NO. 27							
LLoads	28	.0000E+00	.5519E+03	.0000E+00	.2165E-05	.0000E+00	.4189E+04
LLoads	29	.0000E+00	-.5519E+03	.0000E+00	-.2165E-05	.0000E+00	.4829E-07
Stress	28	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	-.9464E+03	.0000E+00
Stress	29	.0000E+00	.1752E+03	.0000E+00	-.1039E-04	.1091E-07	.0000E+00

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

Load Case 1:Cool-off in load position

MAXIMUM STRESS SUMMARY FOR BEAMS/TRUSSES
WITHIN SPECIFIED RANGE 1- 27

Maximum (absolute) Stress = .4770E+05 at BEAM 4

Beam	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
4	.0000E+00	.7357E+04	.0000E+00	-.1482E-04	-.4770E+05	.0000E+00

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FMC CORPORATION S/N:8-0484 01-28-87
PAGE 1

============== I M A G E S 3 D ==============
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==

SOLVE REACTIONS Version 1.3 03/01/86

LTHD barrel and rail under rifling torque load

Load Case 1:Cool-off in load position

REACTIONS

Node	Fx	Fy	Fz	Mx	My	Mz
1	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
5	.0000E+00	.3295E+05	.0000E+00	.4961E-05	.0000E+00	.0000E+00
18	.0000E+00	.6087E+04	.0000E+00	.4898E-05	.0000E+00	.0000E+00
30	.0000E+00	-.9774E+04	.0000E+00	.0000E+00	.0000E+00	.0000E+00
31	.0000E+00	-.2793E+05	.0000E+00	.0000E+00	.0000E+00	.0000E+00
32	.0000E+00	.7936E+04	.0000E+00	.0000E+00	.0000E+00	.0000E+00
33	.0000E+00	-.8707E+04	.0000E+00	.0000E+00	.0000E+00	.0000E+00
34	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
35	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00
36	.0000E+00	-.5519E+03	.0000E+00	.0000E+00	.0000E+00	.0000E+00

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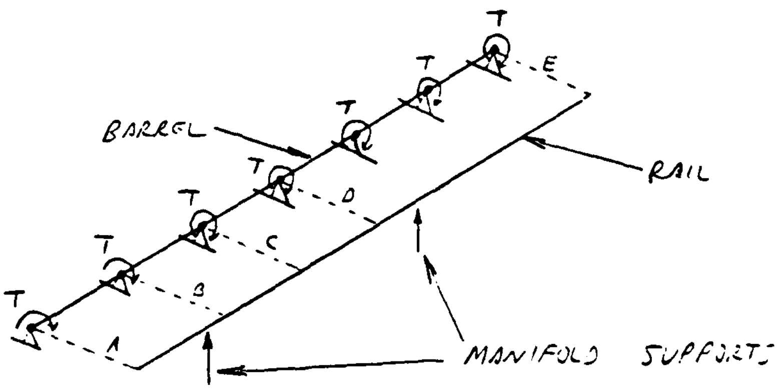
Minneapolis

APPLIED MECHANICS

Subject	Analyst	
LTHD	[illegible]	
	Project Number	
	EC. No.	Date 1-10-87

B) RAILS

— RIFLING TORQUE A FINITE ELEMENT MODEL OF THE BARREL AND ONE RAIL WAS USED FOR ANALYSIS. TORQUE WAS ASSUMED TO BE EQUALLY DISTRIBUTED ALONG THE BARREL.



THE BEAM WAS ANALYZED FOR "COOK-OFF" IN THE LOAD POSITION (COLLAR "B" IN MANIFOLD) AND AN INTERMEDIATE POSITION (MANIFOLD BETWEEN "A" AND "B" COLLARS). STRESSES IN THE "LOAD" POSITION ARE LOW – BENDING STRESS IS 720 PSI. IN THE INTERMEDIATE POSITION, BENDING STRESS IS 79,480 PSI, 59% ABOVE YIELDING. IF THIS IS ACTUALLY A REALISTIC CONDITION, THE RAIL MUST BE STRENGTHENED (LARGER SECTION, MORE SUPPORTS, WIDER MANIFOLD, ETC.).

DA-6490ct85

PART NUMBERS: 12585782, Clamp Plate machining,
12586016-002, Clamp Plate extrusion

DESCRIPTION: RAIL-TO-COLLAR CLAMP

All clamp plates are identical in the cannon assembly to simplify manufacturing. 6061 Al/20 v/o SiCp was chosen because of its high strength/weight ratio as well as its relatively high ductility (compared to higher volume percents of SiCp). An FEA model was created to determine allowable stresses in the clamp plate. It was concluded that a gap not greater than .004 inch should be maintained between the clamp plate and the collars prior to tightening the clamp plate bolts in order to prevent overstressing of the clamp plate. A summary of the FEA results and the complete analysis can be found in the following pages of this section.

STATUS:

Dimensions and tolerances for the clamp plate design (TDP, Dwgs. 12585782 - machining, 12586016-002 - extrusion) are complete and are supported by thorough analysis.

AUTHORS: Joe Fishbein, Joe Turek, Scott Dacko, Dave Warwick

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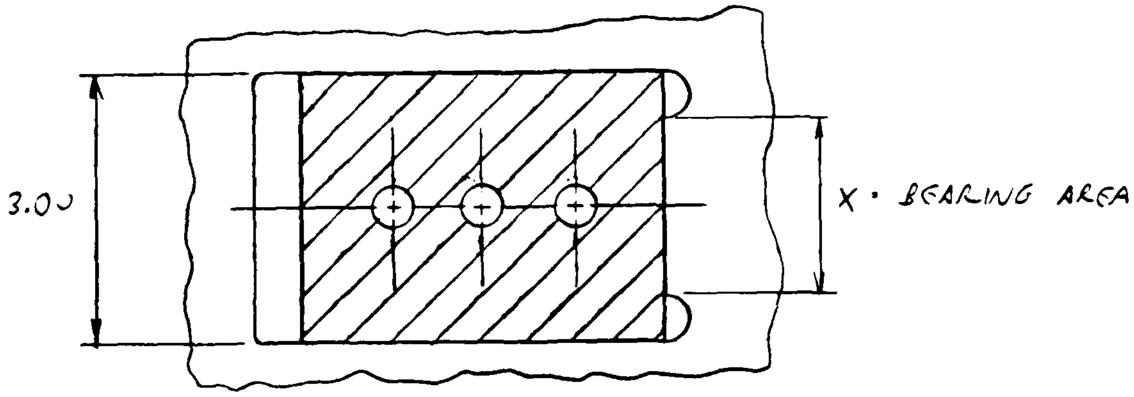
APPLIED MECHANICS

Subject	Analyst	
LTHD	GMF	
	Project Number	
	EC. No.	Date 3-10-87

MODIFY RAIL OPENING FOR MFG.



RECOILING WT = 271.84 lb
A = 438 G (PER S. DACKO 2/23/87)

F = 119,066 lb OR 59533 lb PER SIDE

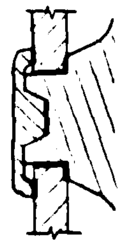
THICKNESS = .515 in

FOR 1/4" R CUTOUTS, X = 2.00 in A = 1.03 in^2

$\sigma_{brg} = \frac{59533 \text{ lb}}{1.03 \text{ in}^2} = 57,799$ psi

FS = 2.08 Ti COLLAR (σ_y = 120 KSI)
FS = 1.64 RAIL (σ_y = 95 KSI)

ACTUAL STRESS WILL BE LESS SINCE FRICTION BETWEEN RAIL AND COLLAR/CLAMP BAR WILL CARRY SOME LOAD



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LFBR
TOTAL WEIGHT = 3870.15
C.G. X COORD (IN) = -.274826
C.G. Y COORD (IN) = -.119819
C.G. Z COORD (IN) = 199.476
JYZ (FT-LB-S^2) = 35568.8
JXY (FT-LB-S^2) = 3.24387
JXZ (FT-LB-S^2) = 35571

DESCRIPTION	WEIGHT	X	Y	Z
5725	5	-13.5	10.88	118
5726	1	-11.5	1.25	105.48
5727	1	-4.25	2.5	105.48
5728	8.76	5	8.75	216.27
5766 MUZZLE BRAKE	181	0	-1.8	366.7
5781.01 REAR	26.8	0	0	128.747
5781.02	16.82	0	0	164.747
5781.03 COLLARS	19.44	0	0	200.057
5781.04	22.77	0	0	237.747
5781.05 FRONT	27.66	0	0	340.997
5782 CLAMP BAR	12.33	0	0	214.45
5786 KEY MUZZLE BRAKE	1	0	4.03	349.8
5787 THRUST COLLAR	24	0	0	347.8
5788 IB BAND	24.67	0	0	189.01
5789 BREECH	495	-2	0	113.2
5802 FLANGE BUTTWASHER	45	-2	-1	105
5816 OB BAND	92.15	0	0	188.13
5947	91.22	0	0	178.125
5948	91.5	0	0	178.125
5954	3.652	0	0	120.623
5955	5.842	0	0	118.807
5963 LH RAIL	86.43	7.38	-2.72	234.577
5964 RH RAIL	79.11	-7.38	0	234.577
5965 KEY, RING	.17	3.62	6.28	120.371
5966 KEY, BREECH	.33	3.62	6.28	120.8
5967 CLAMP RING	1.06	0	0	121.25
5968 KEY	4.78	0	0	214.45
5969 KEY	7.4	0	0	214.43
6002.01	.05	0	4	349
6002.02	6.36	0	0	214.457
6002.02	6.25	0	0	214.457
6002.03	.6	0	0	121.25
6033	1	0	0	207.13
9999	2480	0	0	203.857

TOTAL RECOIL WT = 303.54

REAR COLLAR PARTS:

5781.01	26.8
5782 * (1/5)	2.47
5968 * (1/5)	0.96
5969 * (1/5)	1.48
	31.70 lb

NET WT. OF RECOILPARTS = 271.84 lb

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Minneapolis

APPLIED MECHANICS

Subject	Analyst	
	Project Number	
	EC. No.	Date

COLLAR/RAIL CONNECTION

a) TORQUE LOAD

SHEAR STRESS IN KEY
BEARING STRESS – KEY TO COLLAR
" " – COLLAR TO RAIL

b) CLAMPING FORCE

X BOLT TENSION NECESSARY TO CLOSE COLLAR/CAP GAP
X BEARING STRESS – CAP ON RAIL
X " " COLLAR ON RAIL
X " " KEY ON COLLAR
X BENDING IN CLAMP

Sheet ___ Of ___

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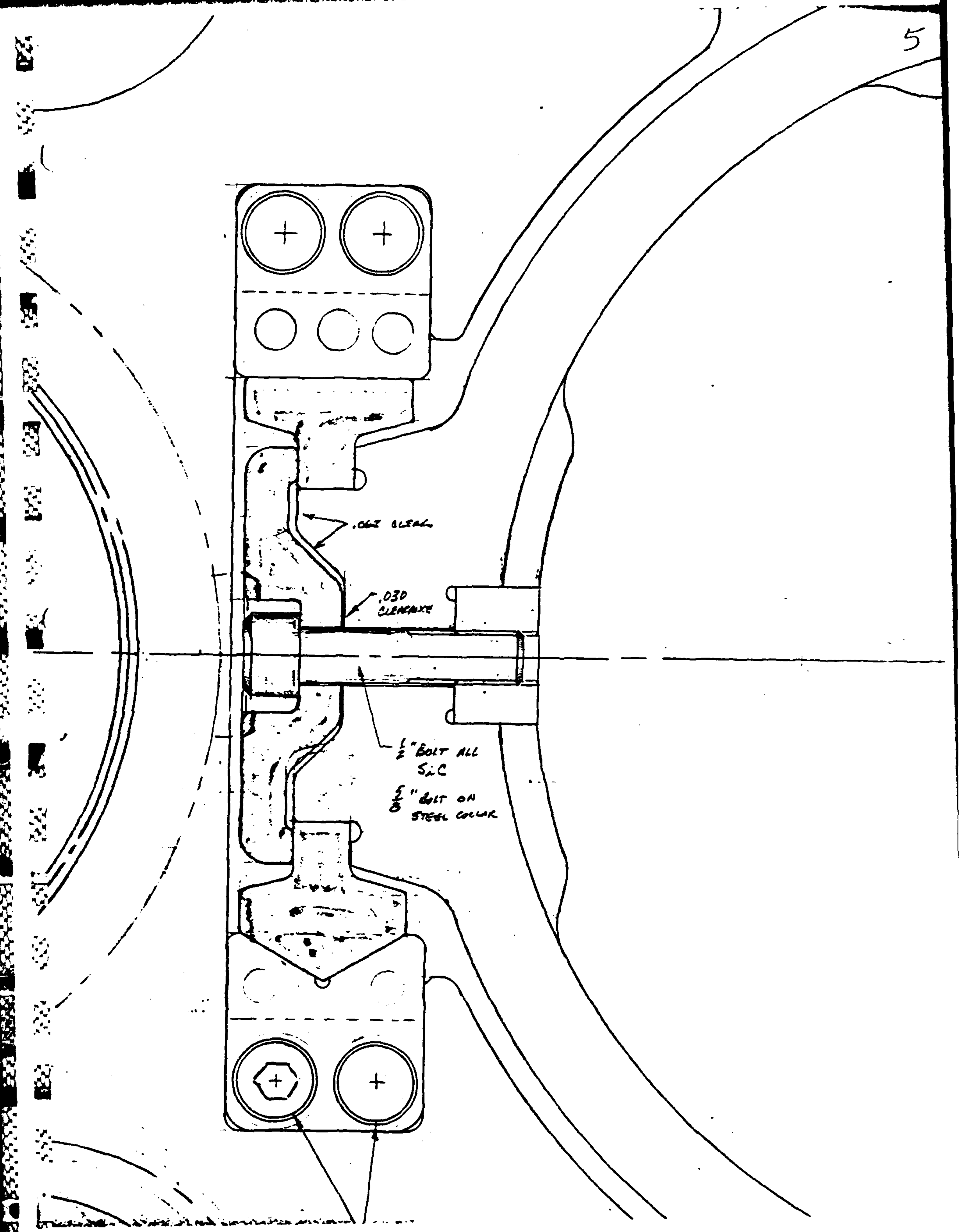
.062 CLEAR
.030 CLEARANCE
1/2" BOLT ALL SiC
5/8" BOLT ON STEEL COLLAR

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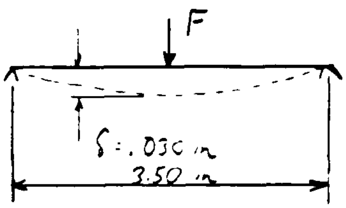
APPLIED MECHANICS

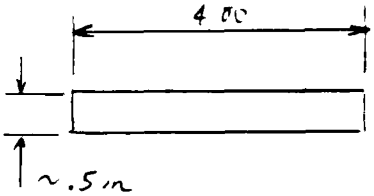
Subject	Analyst	
LTHD	JMF	
	Project Number	
	EC. No.	Date 1-30-87

CLAMPING FORCE

DETERMINE FORCE THAT WILL CLOSE .030" GAP BETWEEN CLAMP AND COLLAR

APPROXIMATE FORCE:





$$I = \frac{(4)(.5)^3}{12} = .0417\ in^4$$

MAT'L - 6061 Al / 20 v/o SiCp

$E = 15 \times 10^6\ psi$

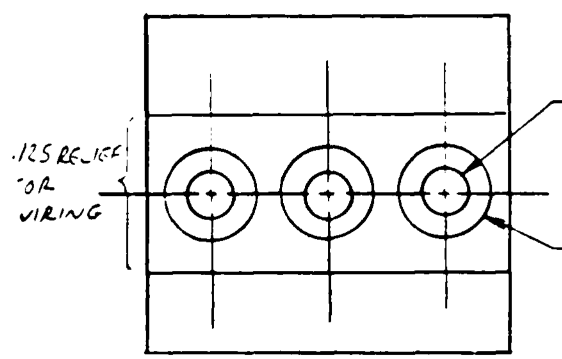
$\sigma_y = 60\ ksi$

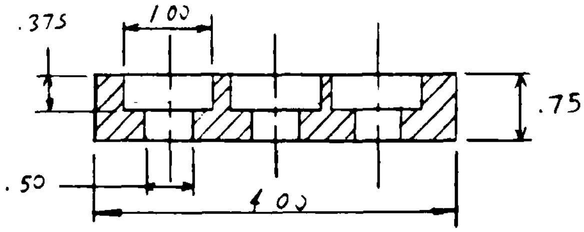
$\sigma_{TS} = 72\ ksi$

$$\delta = \frac{P\ell^3}{48EI} \qquad P = \frac{48EI\delta}{\ell^3} = \frac{48(15\times10^6 psi)(.0417\ in^4)(.030\ in)}{(3.50)^3}$$

$$= 20991\ lb$$

SECTION @ CENTER





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APPLIED MECHANICS

Subject	Analyst	
LTHD	Project Number	
	EC. No.	Date 1-30-87

$$A = (4.00)(.75) - 3(1.00)(.375) - 3(.50)(.375) = 1.3125 \text{ in}^2$$

$$\bar{X} = \frac{-3(1.00)(.375)(.1875) + 3(.50)(.375)(.1875)}{1.3125} = -.0804 \text{ in}$$

$$I_z = \frac{(4.00)(.75)^3}{12} + (4.00)(.75)(.0804)^2 - 3(1.00+.50)(.375)^3/12$$

$$- 3(1.00)(.375)(.1875+.0804)^2 - 3(.50)(.375)(.1875-.0804)^2$$

$$= .0531 \text{ in}^4$$

$$S = I/(.375+.0804) = .1165 \text{ in}^3$$

FOR $FS = 2.0$, $\sigma_{b\,max} = 30$ KSI

$$M_{max} = (\sigma_b)(S) = 3496 \text{ in.lb}$$

$$P_{max} = \frac{4M}{L} = 3996 \text{ lb}$$ OR 1332 lb PER BOLT

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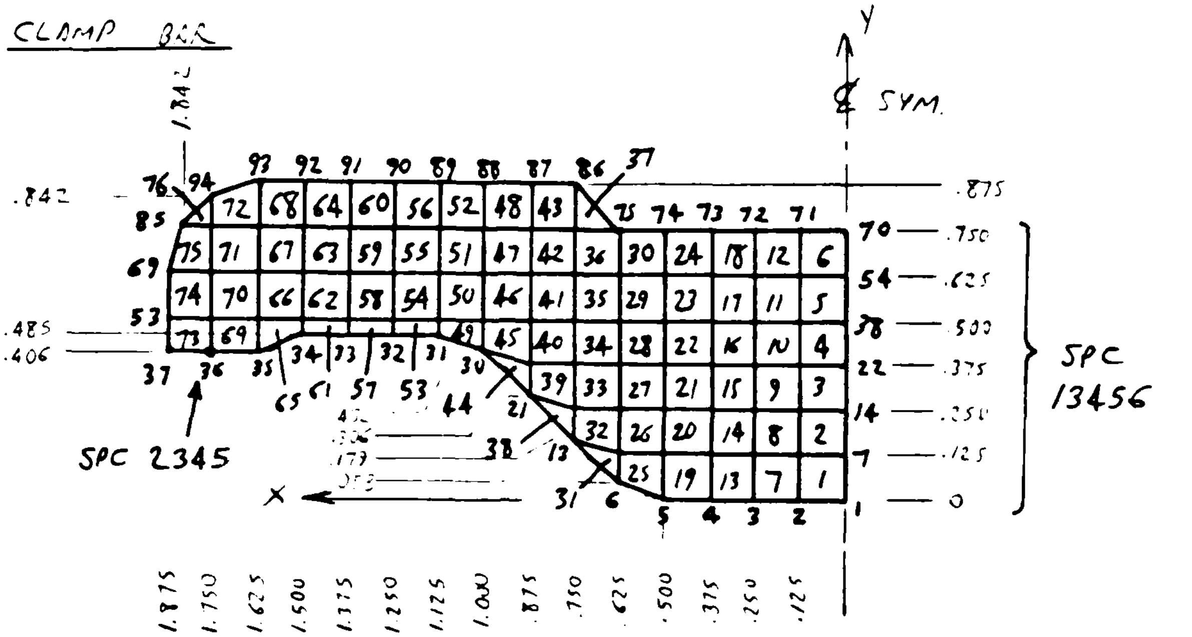
APPLIED MECHANICS

Subject	Analyst	
LTHD	Project Number	
	EC. No	Date

CLAMP BAR



MAT'L : 6061-Al / 20 v/o SiCp

THK = .04 in (1/100 of FULL PIECE)

E : 15×10^6 psi

ρ : .104 lb/in^3

ν : .23

LOAD : 13.32 lb @ SYMMETRIC BOUNDARY

2.220 lb @ NODES 7, 14, 22, 38, 54
1.110 lb @ NODES 1, 70

} IN −2 DIRECTION

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APPLIED MECHANICS

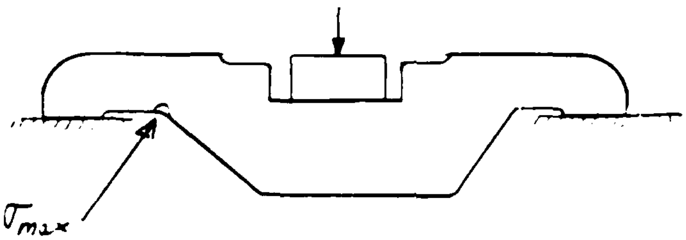
Subject	Analyst	
LTHD	JMF	
	Project Number	
	EC No.	Date 1-30-87

RESULTS OF FEA

37.96 lb LOAD ON 1/100 MODEL SLICE

Δ @ CENTER/BOTTOM (NODE 1) : −.0074 in

σ_{max} = 26,190 psi ON BOTTOM SURFACE @ BEND (ELT. 49)



FOR FS = 2.0, REDUCE LOAD BY $\frac{15000}{26190}$ = .573

Δ_{max} = .0042 in

P_{max} = 3996 lb (.573) = 2289 lb OR 763 lb/BOLT

→ SET GAP TO .004 in TO PREVENT OVERSTRESSING OF CLAMP BAR

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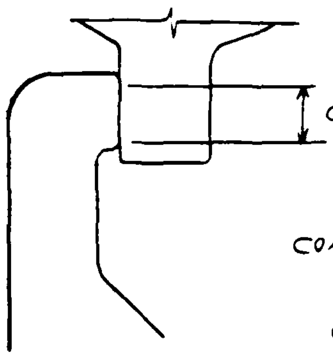
APPLIED MECHANICS

Subject	Analyst	
LTHD	JHP	
	Project Number	
	EC. No.	Date 1-30-87

BEARING STRESS ON RAIL

a) CLAMP TO RAIL



CONTACT AREA = 2(4.00 in)(.19 in) = 1.50 in²

$\sigma_c = \frac{2289 \text{ lb}}{1.50 \text{ in}^2} = 1510$ psi

BEARING STRESS – KEY TO COLLAR – ASSUME GR 8 STEEL BOLTS

BOLTS TIGHTENED TO MAX. ALLOWABLE LOAD

FROM FMC/NOD STD MD24.10, MAX LOAD FOR 1/2" Ø BOLTS = 12,800 lb

This is ≈ 65-75% F_y

FOR FS = 2.0 on YIELDING $T = \frac{(12,800 \text{ lb})}{(.65)}\left(\frac{1}{2}\right) = 9846$ lb

TOTAL LOAD = 3(9846 lb) = 29538 lb

KEY/COLLAR CONTACT AREA = 2(4.00 in)(~.21 in) = 1.68 in²

$\sigma_c = \frac{29538 \text{ lb}}{1.68 \text{ in}^2} = 17582$ psi

$FS = \frac{60000 \text{ psi}}{17582 \text{ psi}} = 3.41$

DA-6490ct85

DESCRIPTION: SLINGING AND TIEDOWN PROVISIONS

Slinging Provisions. The slinging system consists of two slinging provisions on the sides of the top part of the platform and two provisions on the sides of the top part of the front cradle manifold. The platform provision design consists of bolt-on angled, 1/2 inch titanium plates with 3" diameter holes for the sling hooks. The front manifold provisions are similar in design and are envisioned to be aluminum. The lifting slings attach at the four locations and converge at a ring 20.8 ft up vertically from the LTHD center of gravity in the tow position. Calculated cable tensions for the front and rear cables are 2038 lbs and 3577 lbs, respectively. The cable and slinging provision strength requirements are thus to withstand working loads without permanent deformation of 6522 and 11,447 lbs. respectively and have ultimate strengths of greater than 9782 and 17168 lbs. respectively. Hand calculations indicate this lightweight design will easily meet these requirements.

Tiedown provisions. The front tiedown provision is at the lunette. Configuration for other tiedown provisions have yet to be finalized. The requirements of MIL-STD-209F above, along with information on rail car transport and aircraft transport are to be used in finishing the tie-down provision designs.

STATUS:

Slinging and tiedown loads and locations and critical dimensions for the slinging provisions have been determined. FMC has used MIL STD-209F, "Slinging and Tiedown Provisions for Lifting and Tying Down Military Equipment" as the basis for slinging and tiedown requirements.

AUTHOR: Scott D[illegible]

PART NUMBERS: 12585820, Spade weldment
12585821, Spade machining

DESCRIPTION: SPADE

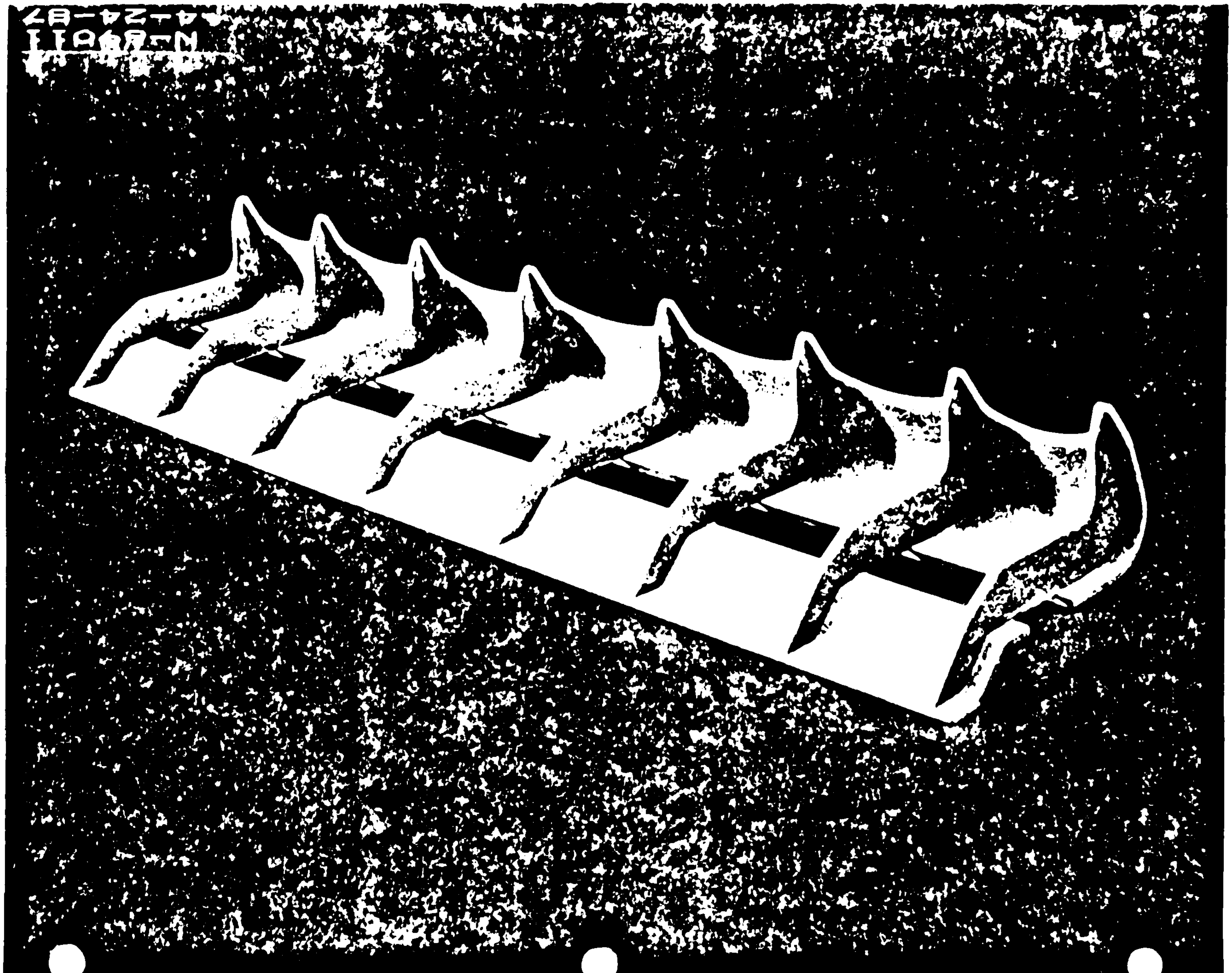
The spade is a machined titanium weldment and weighs 221 lbs. Factors driving the spade design include: the vertical area required to minimize skid under worst-case firing conditions (at 0 degrees QE and all traverse angles); the effects of the horizontal area on ground pressure and in reducing hop; penetrability in hard ground during emplacement; extraction forces required to remove the spade from muddy ground; strength to withstand point and edge loading from rocks, etc.; ground clearance requirements during towing and C130 loading/unloading.

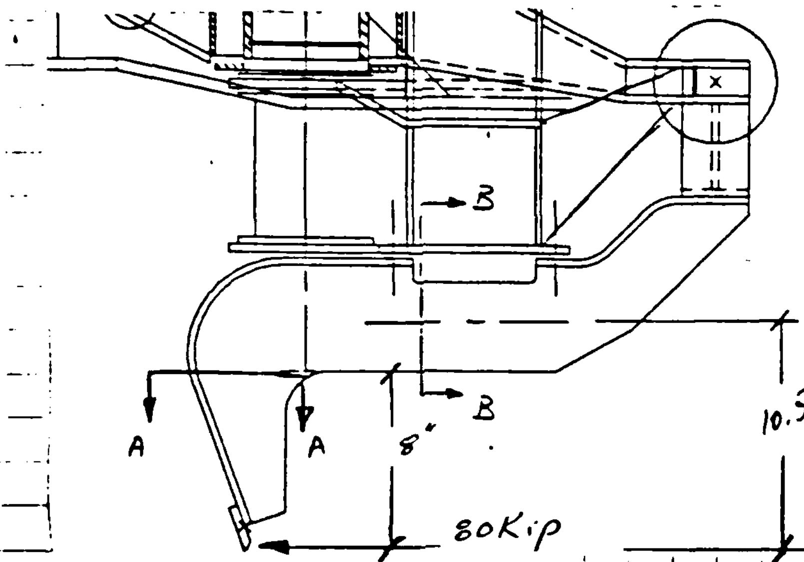
FEA models were used to minimize weight thus far and plans were being developed for structural testing to reduce the spade weight even further. Testing at Aberdeen Proving Grounds would be useful to prove the spades' functionality under the many conditions described above. Load cases and design calculations for the spade can be found in the following pages of this section.

STATUS:

All design and drawing requirements for the spade have been completed. Drawings for the spade can be found in the TDP.

AUTHOR: Dave Langerud





SECAA

$$\sigma = \frac{8(80)}{15.955} = 40\ KSI$$

Platform Torque $80(16) = 1280$

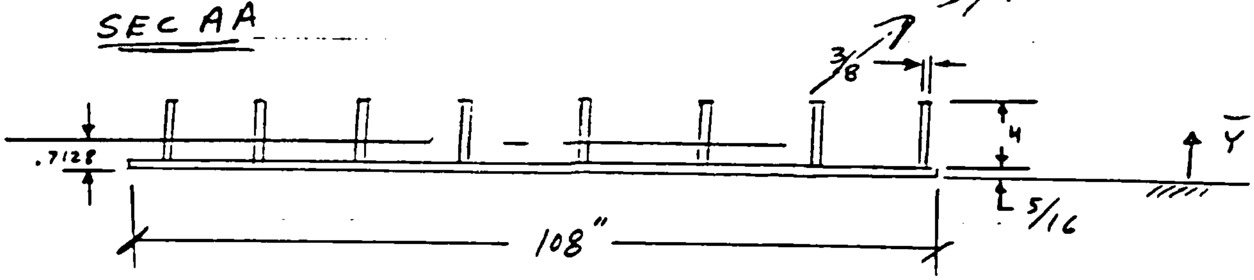
$$\tau_T = \frac{1}{3}\,\frac{1280}{2(5.65)^2(.312)} = 21\ ;\quad \tau = \frac{1}{2}\,\frac{1280}{2(7.375)(7.65)(.312)} \approx 18$$

IF Gussets 5/16

$$\sigma = \frac{8(80)}{13.505} = 47.39\ KSI$$

5/16 Gussets

SEC AA



$$\Sigma A = \underbrace{108(5/16)}_{33.75} + \underbrace{8(\cancel{3/8}\ 5/16)(4)}_{\cancel{12}\ 10} = \cancel{45.75} \rightarrow 43.75$$

$$\Sigma A\bar{Y} = 108(5/16)(5/32) + 8(\cancel{3/8}\ 5/16)(4)(2 + 5/16) = \cancel{33.0234}\ 28.3984$$

$$\frac{\Sigma A\bar{Y}}{\Sigma A} = \cancel{.7218}\ .6491$$

$.7128 - 5/32 = .5566$

$2.3125 - .7128 = 1.5997$

$$I = \frac{108(.3125)^3}{12} + \frac{8(\cancel{3/8}\ 5/16)(4)^3}{12} + 33.75(\cancel{.7218}\ .6491 - \tfrac{5}{32})^2$$

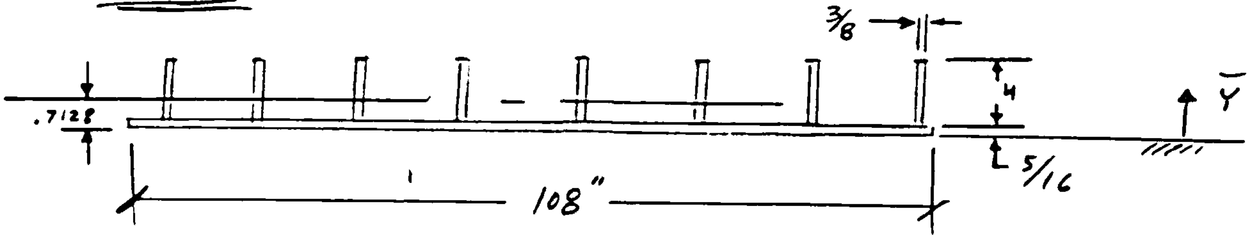
$$+ \cancel{12}\ 10(2.3125 - \cancel{.7218}\ .6491)^2$$

$I = 57.4334$ 49.4749

$Z_1 = 80.5744$ 76.2268

$$Z_2 = \frac{57.4334}{4.3125 - \cancel{.7128}\ .6491} = \cancel{15.9551} \rightarrow 13.505$$

SEC AA



$$\Sigma A = \underbrace{108(5/16)}_{33.75} + \underbrace{8(3/8)(4)}_{12} = 45.75$$

$$\Sigma A\bar{Y} = 108(5/16)(5/32) + 8(3/8)(4)(2+5/16) = 33.0234$$

$$\frac{\Sigma A\bar{Y}}{\Sigma A} = .7218$$

$$.7128 - 5/32 = .5566$$

$$2.3125 - .7128 = 1.5997$$

$$I = \frac{108(.3125)^3}{12} + \frac{8(3/8)(4)^3}{12} + 33.75(.7218 - \tfrac{5}{32})^2$$

$$+ 12(2.3125 - .7218)^2$$

$$I = 57.4334$$

$$Z_1 = 80.5744$$

$$Z_2 = \frac{57.4334}{4.3125 - .7128} = 15.9551$$

SEC BB

5/16 Gussets $Z = 10.42$ $A = 12.5$

$$\sigma = \frac{80(10.5)}{10.42} + \frac{80}{12.5} = 80.6 + 6.4 = 87 \text{ KSI}$$

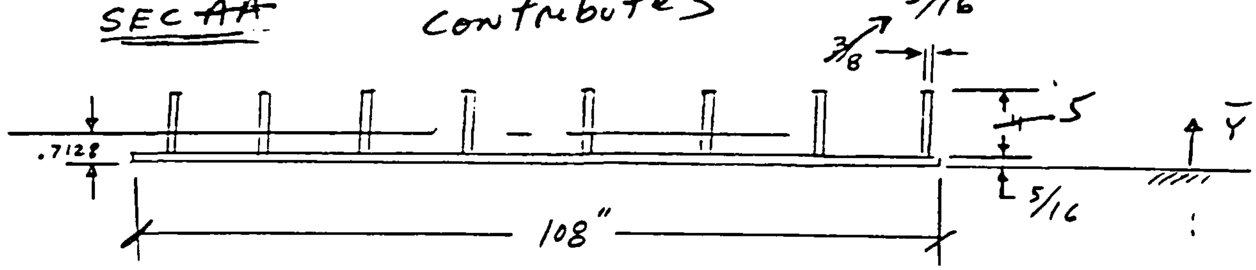
IF Platform Plate Contributes

$$\sigma = \frac{80(13-.8742)}{20.43} + \frac{80}{46.25} = 47.5 + 1.7 = 49.2 \text{ KSI}$$

BB

SEC ~~AA~~

Assume Platform PLT Contributes



$$\Sigma A = \overbrace{108(5/16)}^{33.75} + \overbrace{8(\cancel{3/8}\ {\scriptstyle 5/16})(\cancel{4}\ {\scriptstyle 5})}^{\cancel{12}\ 12.5} = \cancel{45.75}\quad 46.25$$

$$\Sigma A\bar{Y} = 108(5/16)(5/32) + 8(\cancel{3/8}\ {\scriptstyle 5/16})(\cancel{4}\ {\scriptstyle 5})(\cancel{2}\ {\scriptstyle 2\frac{1}{2}} + 5/16) = \cancel{33.0234}\quad 40.4297$$

$$\frac{\Sigma A\bar{Y}}{\Sigma A} = \cancel{.7218}\ .8742 \quad // \quad .7128 - 5/32 = .5566$$

$$2.3125 - .7128 = 1.5997$$

$$I = \frac{108(.3125)^3}{12} + \frac{8(\cancel{3/8}\ {\scriptstyle 5/16})(\cancel{4}\ {\scriptstyle 5})^3}{12} + 33.75(\cancel{.7218}\ .8742 - \tfrac{5}{32})^2$$

$$+ \cancel{12}\ 12.5\,(\cancel{3.3125}\ 2.8125 - \cancel{.7218}\ .8742)^2$$

$$I = 57.4334 = 90.6754$$

$$Z_1 = \cancel{80.5744} \rightarrow 103.7$$

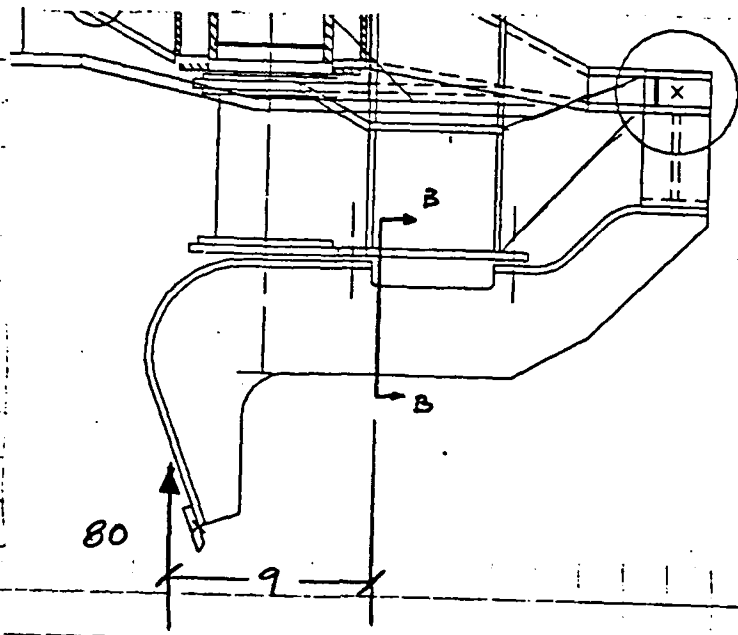
$$Z_2 = \frac{57.4334}{\begin{matrix}4.3125 - .7128\\ 5.3125 - .8742\end{matrix}} = \cancel{15.9551} \rightarrow 20.4302$$

SEC BB

$Z = \frac{8(3/8)4^2}{6}$

$Z = 8$

$A = 12$



SEC BB

$\sigma = \frac{80(9)}{8} = 90\ KSI$

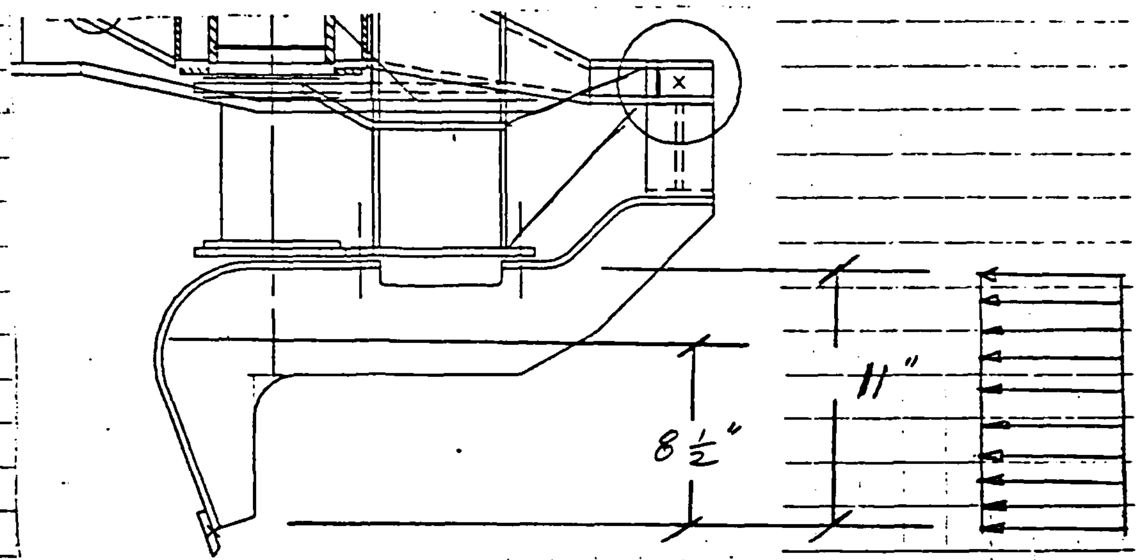
$\tau = \frac{3}{2} \frac{(80)}{8(3/8)4} = 10\ KSI$

SEC BB IF $H = 5''$ $Z = 12.5$

$\sigma = \frac{80(9)}{12.5} = 57.6$

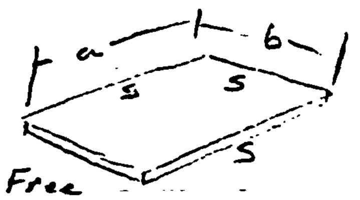
SEC BB IF $H = 5$, $t = 5/16$ $Z = 10.42$

$\sigma = \frac{80(9)}{10.42} = 69.12$



$$\beta = \frac{80,000}{108(11)} = 67.34 \text{ PSI}$$

Bending of Flat Plts Via Roark



Uniform Pressure $p = 67.34$ PSI

$a = 8\frac{1}{2}$ $b = 15$

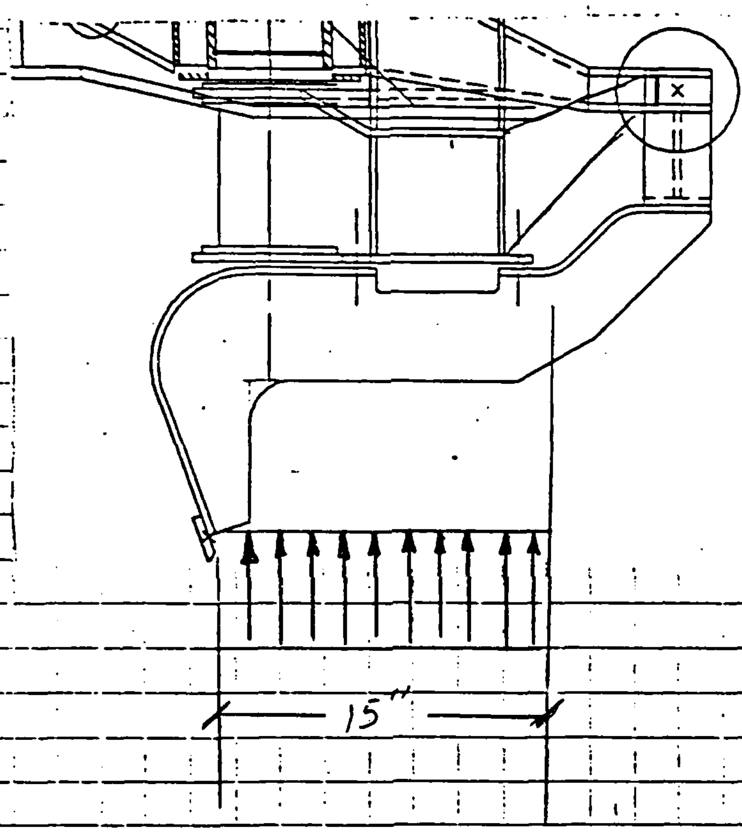
$\frac{a}{b} = .56$ $\beta \doteq .39$

$$\sigma = .39 \frac{(67.34)(15)^2}{(.3125)^2} = 60{,}510 \text{ psi}$$

Try $B = 17$

$\frac{a}{b} = .5$

$$\sigma = \frac{.36(67.34)(17)^2}{(.3125)^2} = 71.75 \text{ Kip}$$



$$P = \frac{80,000}{108\,(15)} = 49.38 \text{ PSI}$$

PART NUMBER: 12585710-575, Speedshift Assembly

DESCRIPTION: SPEEDSHIFT ASSEMBLY

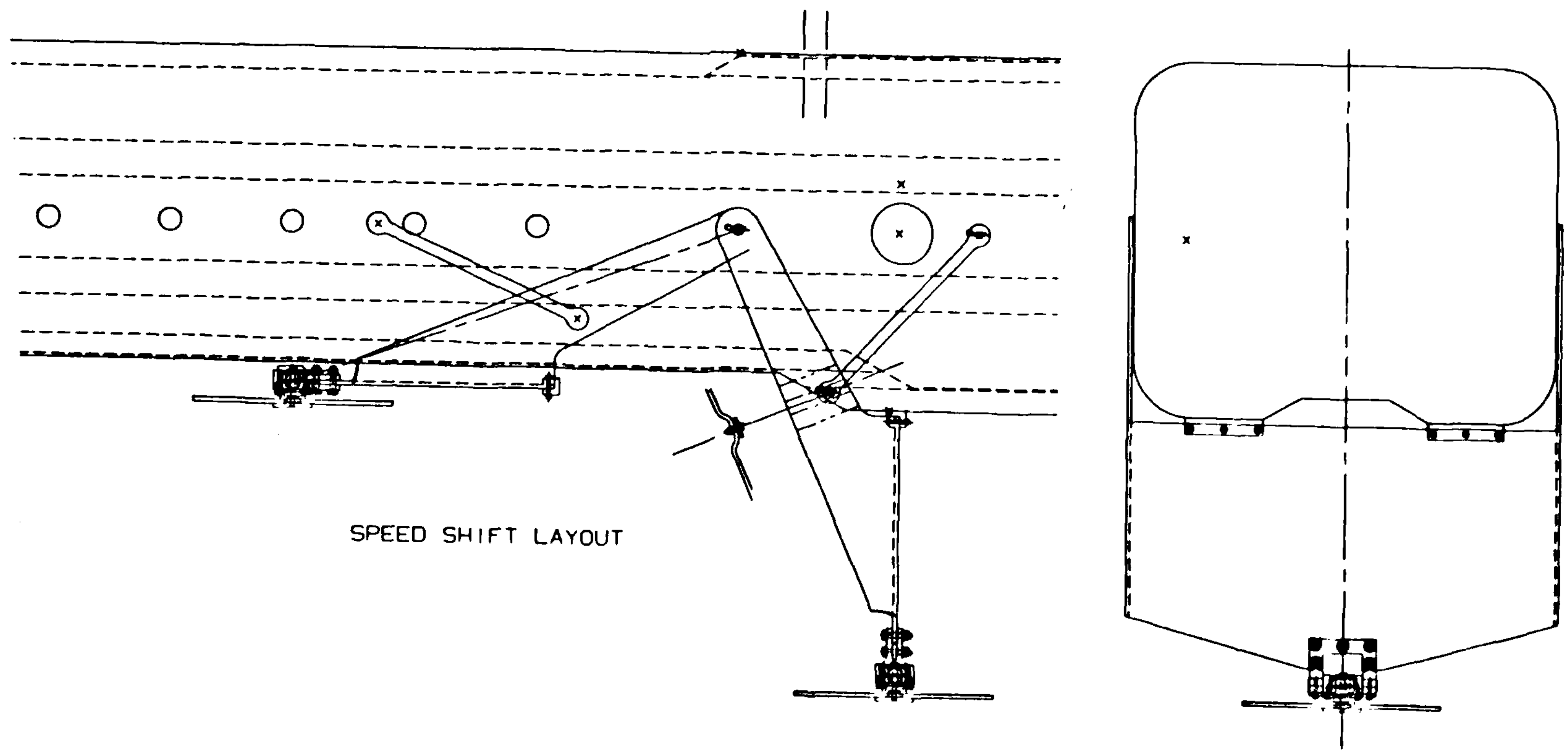
The speedshift assembly is located exactly at the system center of gravity with the system in the tow position and the barrel in the load position. (See Figure D/250-1.) The assembly is stowed in the "up" position when not needed. During the speedshift procedure (see section on operational procedures) the barrel is lowered 300 mils, the assembly is lowered and the weight of the depressed components rests on the assembly. After the barrel equilibration is turned off and the trails are raised, the rear wheels are lowered to lift the spade out of the ground. At this time, the cradle is parallel with the ground and the LTHD is fairly well-balanced on the speedshift assembly and can be rotated about the disk at the assembly base.

The design load for the speedshift assembly consists of the 9000 pound system weight acting perpendicular to the cradle plus-or-minus the angles allowed from "tipping."

STATUS:

A layout of the speedshift assembly (TDP, Dwg. 12585710-575) has been made and preliminary sizes have been determined for the major components. The layout can be found in the TDP.

AUTHOR: Kent Williams



SPEED SHIFT LAYOUT

DESCRIPTION: TRAIL, TRAVEL LOCKS, FIRING LOCKS

The major components of the trail include: the composite trail structure, bulkheads, walking beams, hubs and axles, service and park brakes, wheels and tires and wheel actuators.

Composite Trail Structure -

FMC has worked with both Morton Thiokol and Heath Techna to firm up the trail design and the composite trail structure in particular.

The trail design has changed significantly since the end of Phase I; the primary driver being the incorporation of the wheels (formerly on a dolly) into the trails. Considerable analysis was performed on a design that suffered from weight and producibility problems. Only portions of that analysis applicable to the new design are included.

For a summary of trail load cases and design calculations, the reader is referred to the following pages of this section.

Design requirements for the trail include not only being able to withstand loads induced from worst-case environments, but also to have a minimal amount of deflection at the trail ends in the fire position. Stability analysis indicates that less than 1 inch of static deflection at the trail ends (at 0 degrees QE and traverse) provides acceptable firing stability under worst-case firing conditions. Analysis to date indicates that deflections on the order of 1 inch are attainable.

The following steps summarize the approach used for composite trail structural analysis:

1. Basic hand-analysis was performed to verify structural feasibility.

2. The trail geometry was defined on paper.

3. A 2-dimensional model was created with IDEAS SuperTab Preprocessor.

4. Inputs to the MCS NASTRAN FEC consisted of both shell and beam element data:

Properties of the beam elements were derived from SuperTab. Beam element material constants were determined using COMPCAL, a software package developed by the University of Delaware that runs on an IBM PC.

2
3-BLANK

The shell elements were modelled using ply-by-ply property inputs. Material property inputs consisted of the anisotropic properties of the selected composite pre-preg. These properties included a knockdown factor for hot-wet conditions.

5. Three static load cases were analyzed and include: air transport; towing - worst-case "bump and skid;" and working loads from worst-case firing conditions. For each of these load cases, force inputs and precise constraints were determined. All constraints were assumed rigid. The elasticity of the platform, for example, was thus ignored.

6. The NASTRAN solution sequence was specified. (Superelement static solution 63 was primarily used.)

7. The NASTRAN program was run and paper output was generated.

8. The output was reviewed for low strains, high strains, unacceptable Tsai-Wu values and also maximum strains using the maximum strain failure criterion. (Early Phase II work used Tsai-Wu; later in Phase II, FMC switched to using the maximum strain failure criterion. With this criterion, .006 inches/inch was used to account for damage tolerance. The anisotropic material was analyzed in a ply-by-ply fashion.

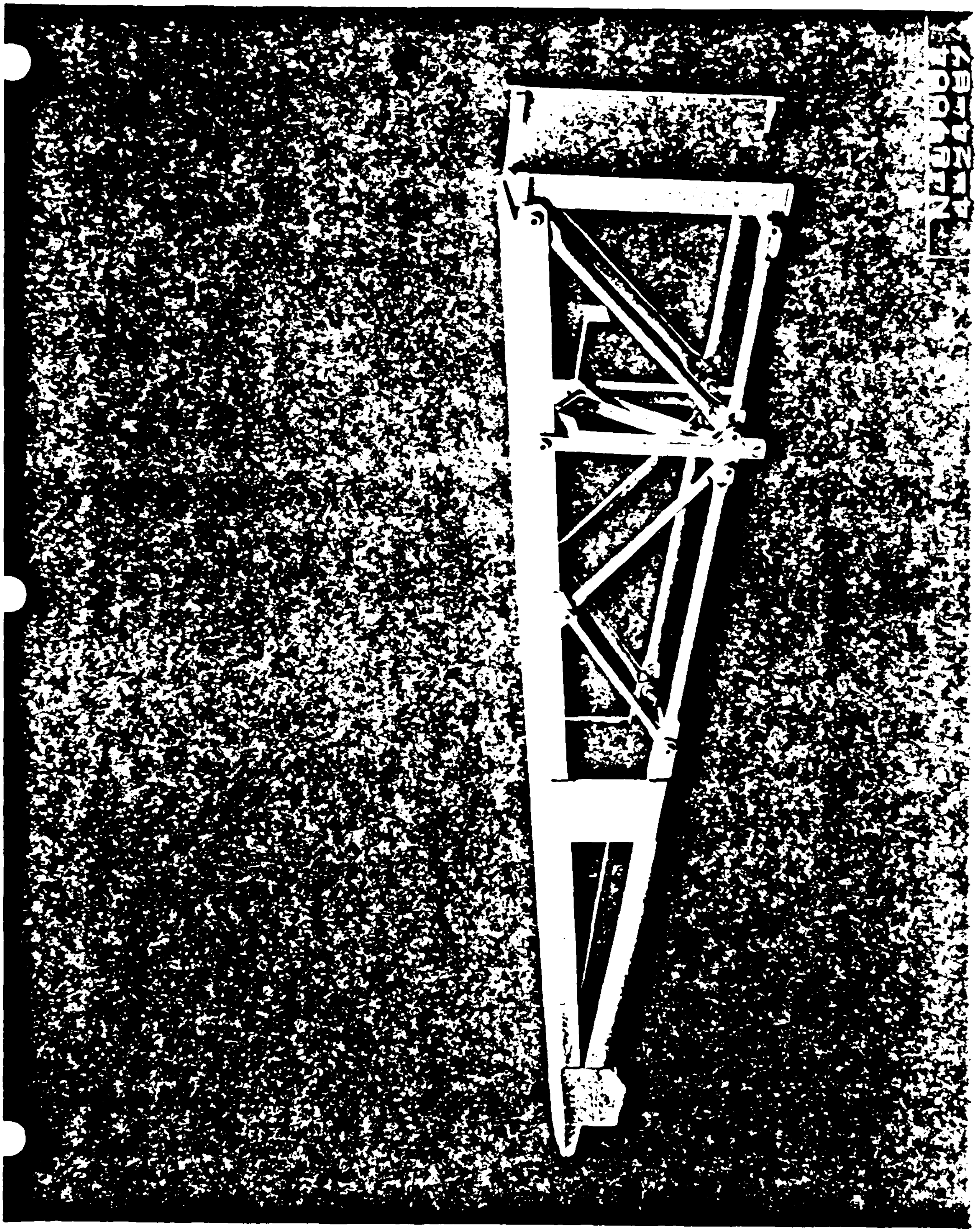
9. Recommendations were made for design changes which could reduce weight, reduce strains and increase stiffness.

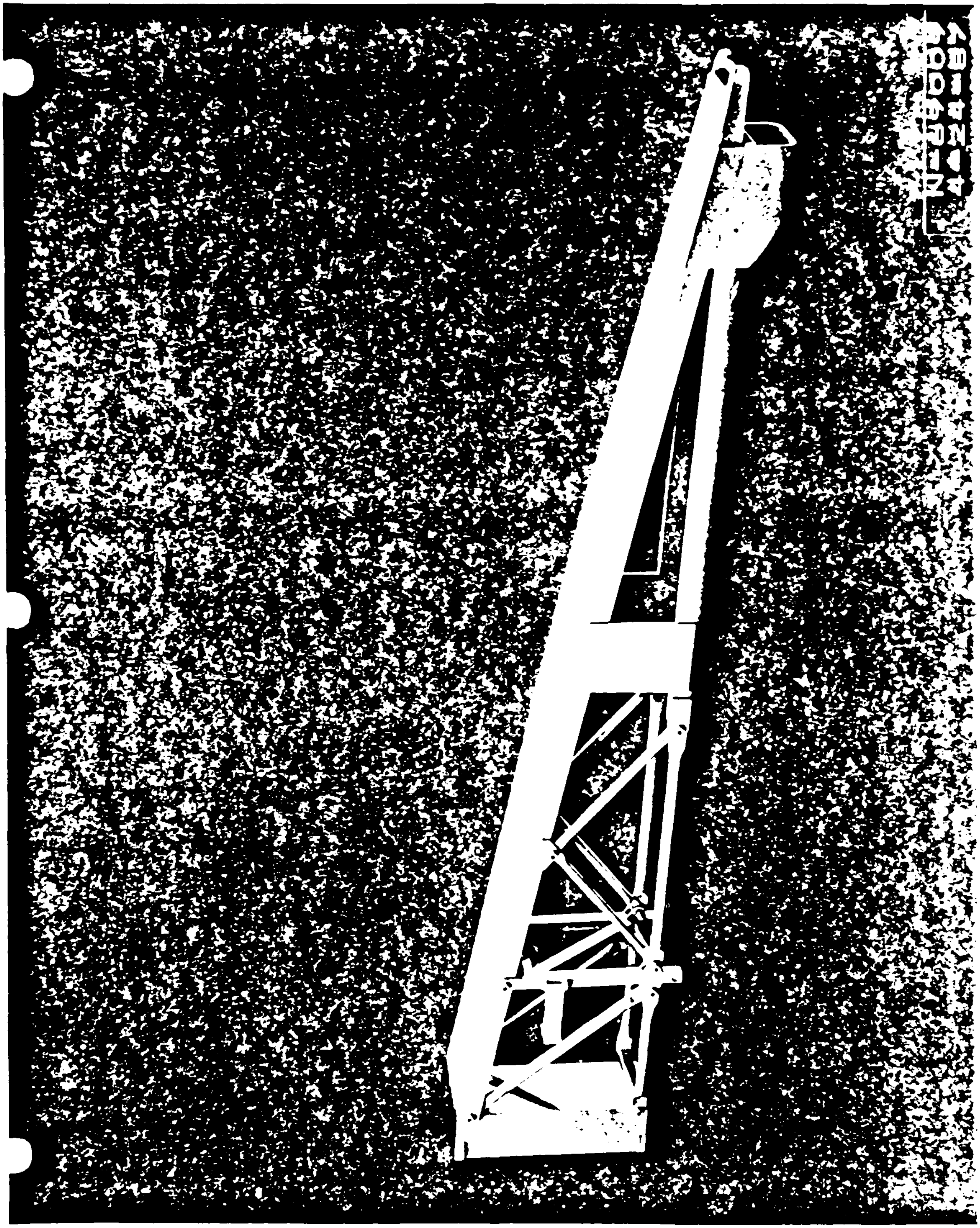
10. The above process was repeated with data modifications to reflect the desired design changes.

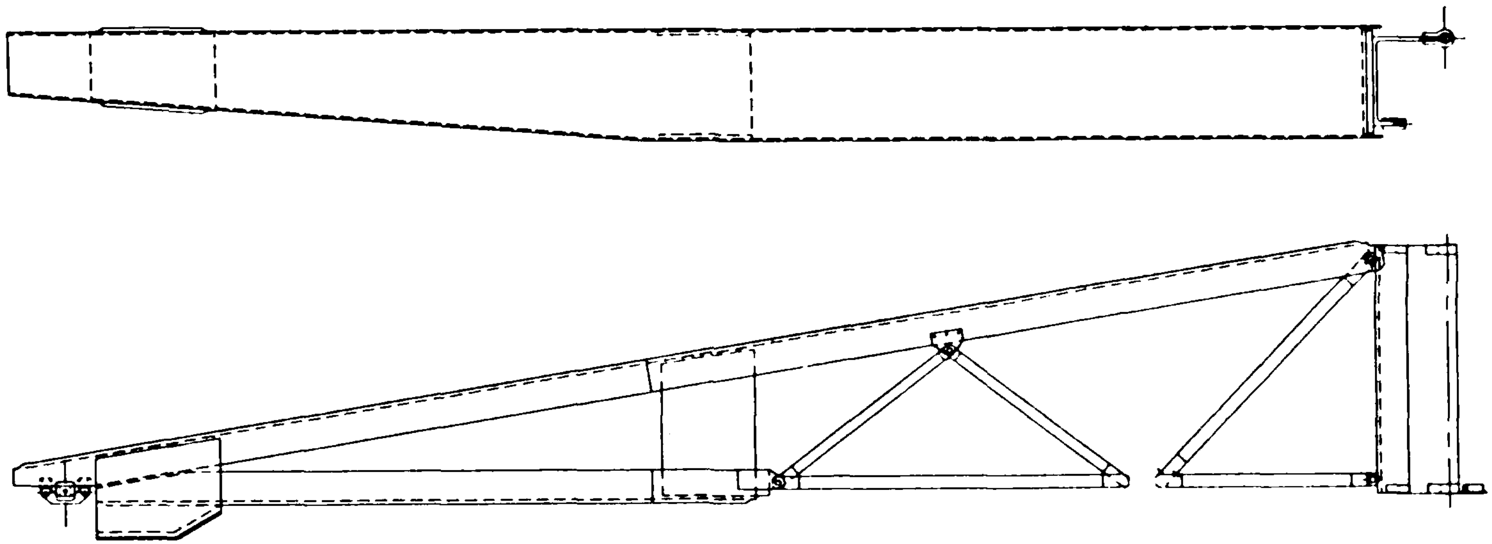
STATUS:

A current layout of the trail (figure D/270-1), along with the current 1/12 scale 3-D model, pages 3-4, best illustrate the trail configuration.

AUTHORS: Diane Tollette, Dave Langerud, Joe Fishbein, Scott Dacko

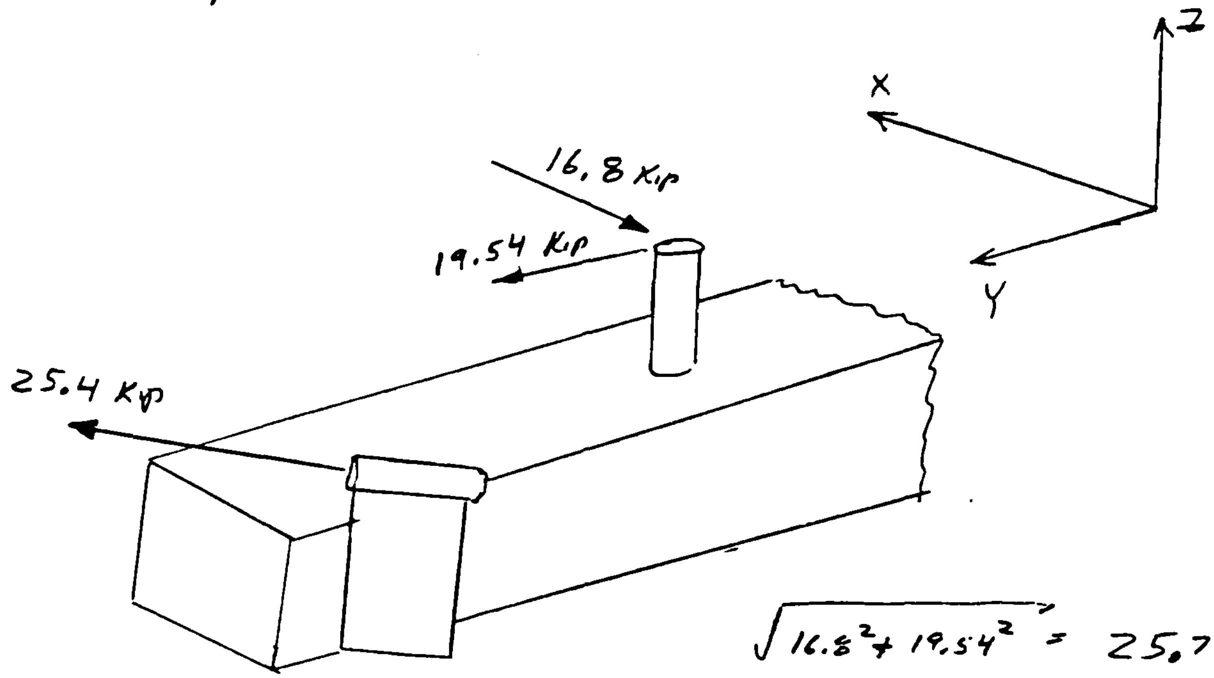






TRAIL LAYOUT.

6) Assume Load evenly Distributed Top To Bottom

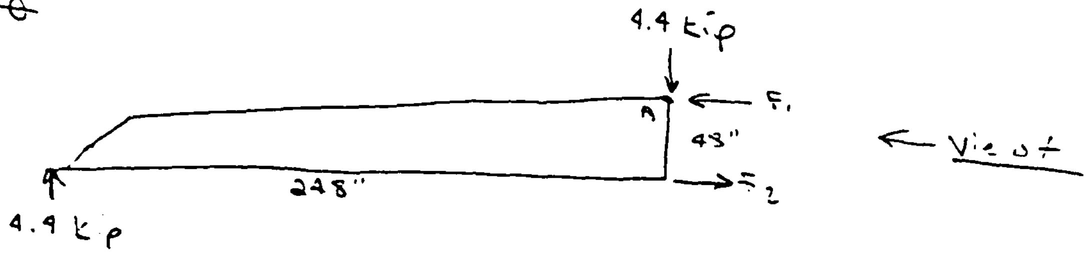


$\sqrt{16.8^2 + 19.54^2} = 25.77\ KIP$

2/13/87 DT

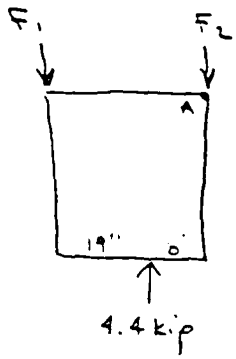
(0° QE, 22.5° TRAV)

Working



$\Sigma M_A = 248 \times 4.4 - 48 \times F_2 = 0$ $F_2 = 22.7$ kip

$F_1 = 22.7$ kip



View A

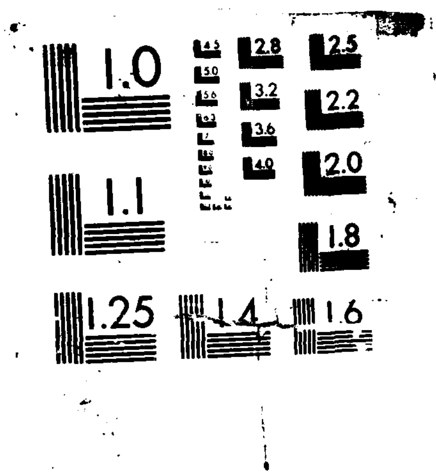
ROTATED 90° CCW

$\Sigma M_A = 6 \times 4.4 - 19 \times F_1 = 0$ $F_1 = 1.4$ kip

$F_2 = 4.4 - 1.4 = 3.0$ $F_2 = 3.0$ kip

AD-A183 988 LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN NORTHERN ORDNANCE DIV R RATHE ET AL APR 87 2/3

UNCLASSIFIED FMC-E-3041-VOL-D1-PT-2 DAAA21-86-C-0047 F/G 19/6 NL



MICROCOPY RESOLUTION TEST CHART

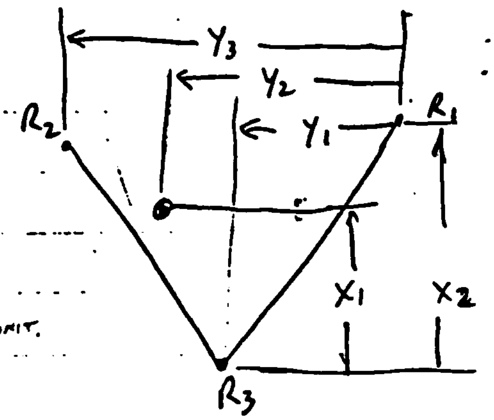
S. Packo
2/13/87

TRAIL L.C. -2

BOTTOM OF PAGE.

1T- ANALYSIS (8702144)

$150 + 77.25 + 150 = \underline{377.25''}$



$X_2 = 262.5 \times \cos 35° = \underline{215''}$

39.6 ". LH WHL UNIT.

LFBS. DAT : BARREL IS AT 0° TRAV.

WT = 8540

$CG_z = 134.92 \Rightarrow X_1 = 134.92 + 24 = 158.9$

$CG_x : 0 \Rightarrow Y_1 = \frac{1}{2} Y_3 = \underline{188.6''}$, $Y_2 = Y_1$

$$R_2 = \frac{W\,(X_1 Y_1 + X_2 (Y_2 - Y_1))}{(X_2 Y_1 - X_2 (Y_1 - Y_3))} = \frac{8540\,(158.9 \cdot 188.6 + 215\,(0))}{(215 \cdot 188.6 - 215\,(188.6 - 377.25))}$$

$R_2 = \underline{\underline{3266.25}}$ LBS.

LFBS FLT. DAT = LFBE. DAT at 22.5° TRAV. + remainder of sys. (LFBNE. DAT)

LFBE. DAT WT = 6077 , CG_z = 184.66 (BARREL - HYD FL.)

at 22.5° TRAV., CG_z = 170.60 , CG_x = 70.67

LFBNE. DAT WT = 2763 CG_z = 25.54".

LFBS FLT. DAT : WT = 8540 , $C.G._z$ = 134.92 , $C.G._y$ = 48.58

$\Rightarrow X_1 = 158.92$, $Y_2 = Y_1 + 48.58 = 237.18''$

$$R_2 = \frac{8540 \cdot (158.92 \cdot 188.6 + 215\,(237.18 - 188.6))}{(215 \cdot 188.6 - 215\,(188.6 - 377.25))} = \underline{\underline{4405 \text{ LBS.}}}$$

Fireing on Frictionless Plane

QE = $\phi°$, TRAVERSE = $22\frac{1}{2}$

Assume
1) STRUCTURE ACTS as Rigid Body
2) Recoil Force is NOT affected By Movement OF Non Recoil Mass
3) ALL energy is Transformed into MOTION OF NON Recoil mass (NON into Hop OR Rotation)
4) Trail wt = 700# @ 90° from Hinge
5) Non Recoil mass = 5100 LBS

RECOIL FORCE = 75,000 LBS

G Load = $\frac{75}{5.1}$ = 14.7 g's

$F_1 = 700\,(14.7) = 10{,}290$ LBs $= 10.29$ Kip

$\Sigma M_Z^{@a} = 0;\ 0 = F_2\,16.25 - 58.38\,(10.29)\cos 22.5 - 69.\,(10.29)\sin 22.5$

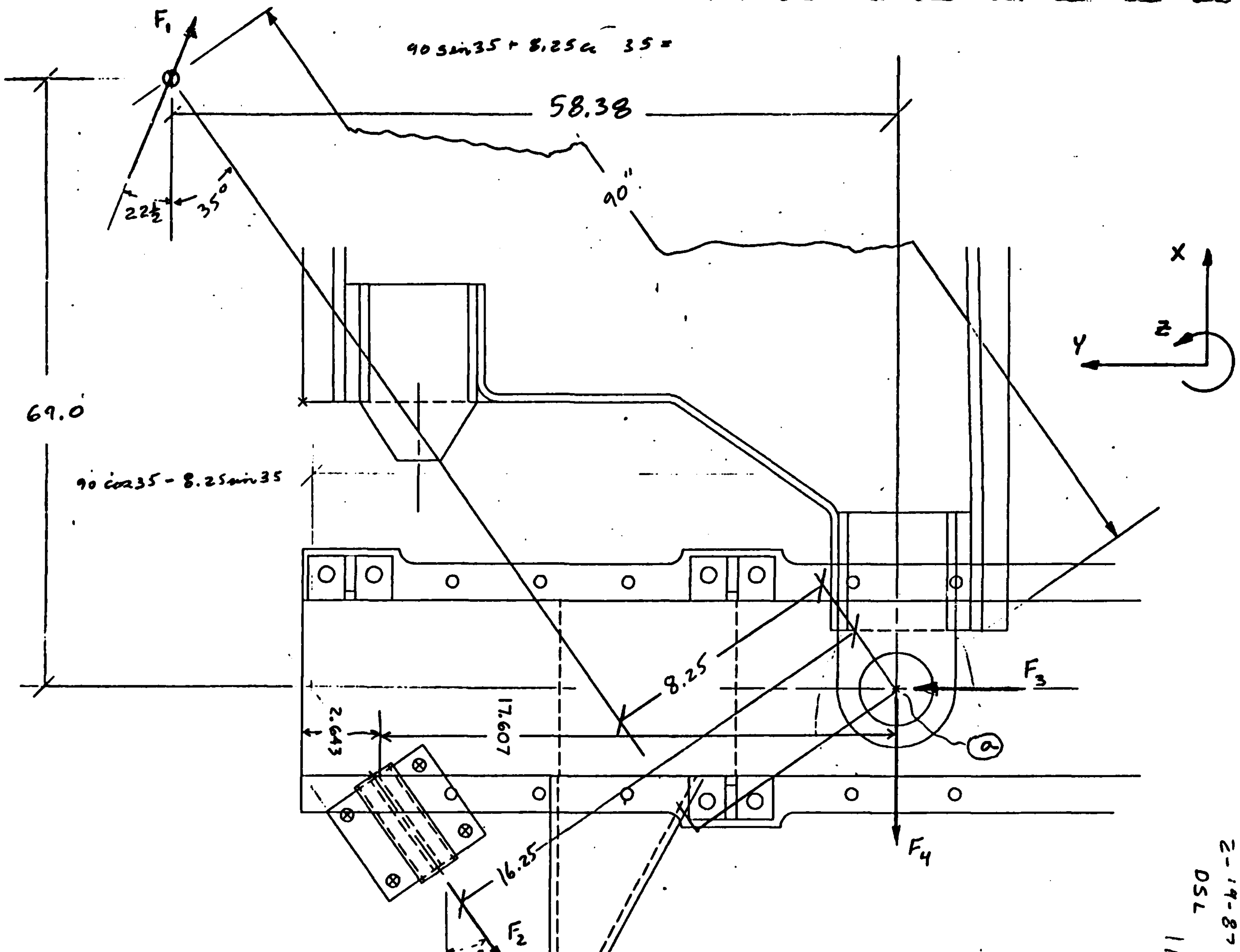
$F_2 = 50.87$ Kip

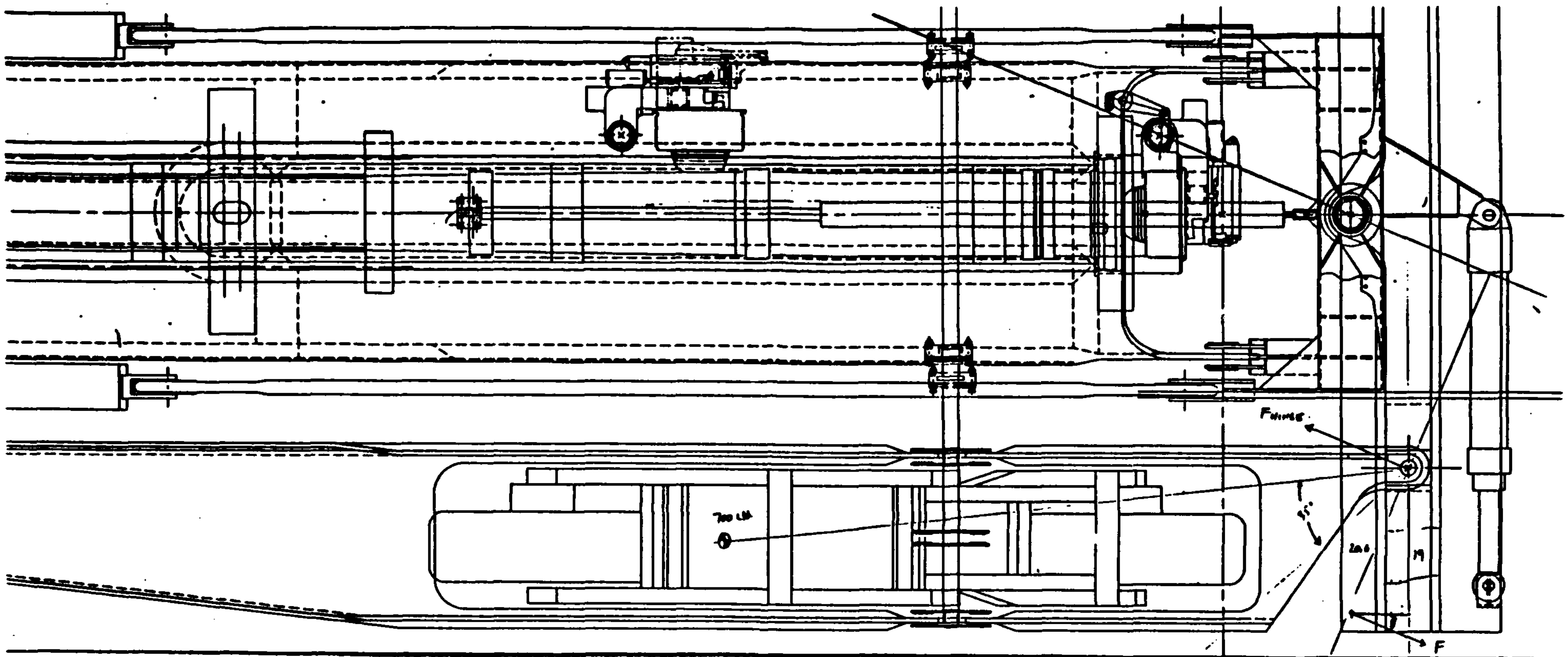
$\Sigma F_x = 0;\ 0 = 10.29\cos 22.5 - 50.87\cos 35 - F_4$

$F_4 = -32.16$

$\Sigma F_y = 0;\ 0 = -10.29\sin 22.5 + F_3 - 50.87\sin 35$

$F_3 = -39.08$


90 sin35 + 8.25 cos 35 =
58.38
90"
X
Y
Z
F_1
$22\frac{1}{2}$
35°
69.0
90 cos35 - 8.25 sin35
8.25
F_3
2.643
17.607
(a)
16.25
F_4
F_2



LOADS AT TRAIL ATTACHMENTS DUE TO FIRING AT 22½° TRAV, 0° QE
w/ 79K RECOIL LOAD ACTING ON NON-RECOIL MASS.

$\curvearrowright + \; \Sigma M_{HINGE} = 0 = (700 \cdot 15.5G)(79.5) - F \cdot 20.6$

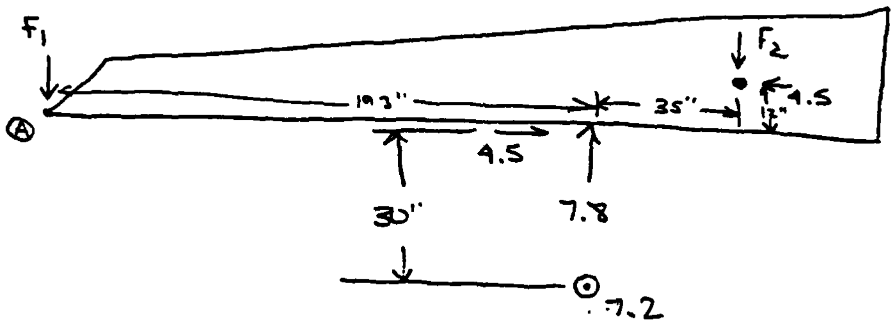
$F = \underline{41,872 \text{ LBS.}}$

$\Sigma F_x = 0 \Rightarrow F_{HINGE} = 41,872 - 10,850 \text{ LBS} = \underline{31,022. \text{ LBS}}$

S. DACKO. 2/13/87

2/13/87 TRAIL LC-9

Bump + Skid

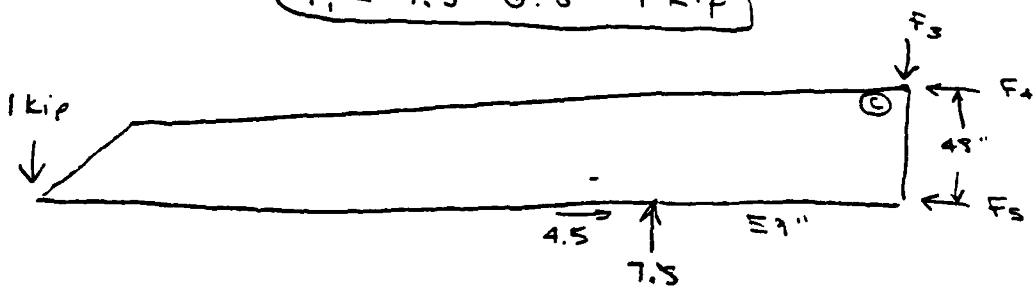


B = Trunnion Centerline

$$\Sigma M_B = 193 \times 7.8 - 228 \times F_2 + 4.5 \times 12'' = 0$$

$\boxed{F_2 = 6.8 \text{ kip}}$

$\boxed{F_1 = 7.8 - 6.8 = 1 \text{ kip}}$



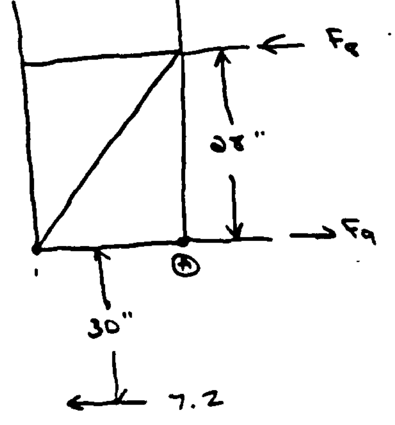
$$\Sigma M_C = 48 \times F_5 + 59 \times 7.8 - 48 \times 4.5 - 252 \times 1 = 0$$

$\boxed{F_5 = .2 \text{ kip}}$

$\boxed{F_4 = 4.3 \text{ kip}}$

$\boxed{F_3 = 6.8 \text{ kip}}$

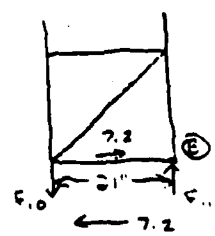
Wheel Bulkhead



$$\Sigma M_A = 30 \times 7.2 - 28 \times F_8 = 0$$

$\boxed{F_8 = 7.8 \text{ kip}}$

$\boxed{F_9 = 15 \text{ kip}}$



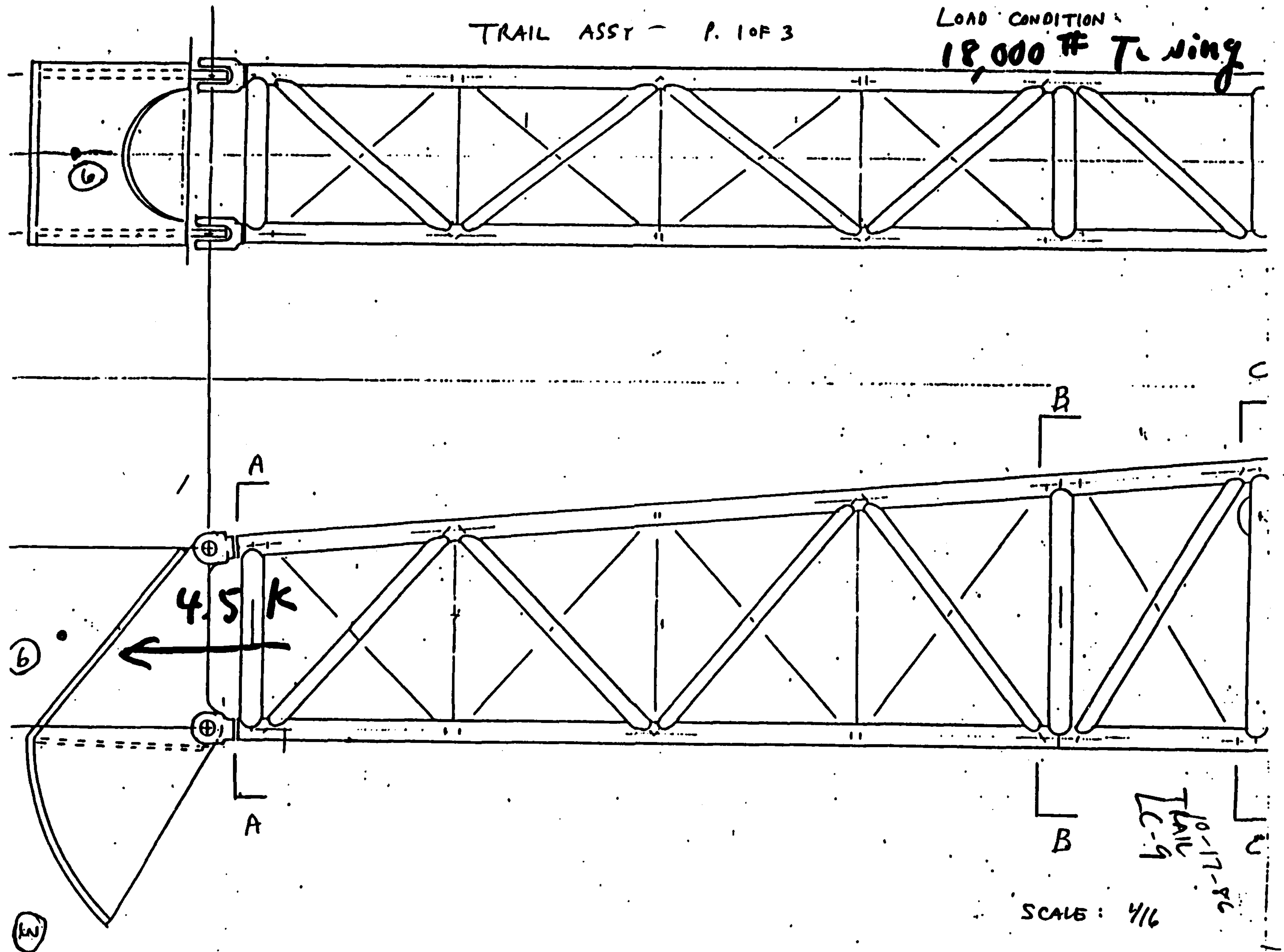
$$\Sigma M_E = 30 \times 7.2 - 21 F_{10} = 0$$

$\boxed{F_{10} = 10.3 \text{ kips}}$

$\boxed{F_{11} = 10.3 \text{ kips}}$

TRAIL ASSY – P. 1 OF 3

LOAD CONDITION:
18,000 # Turning



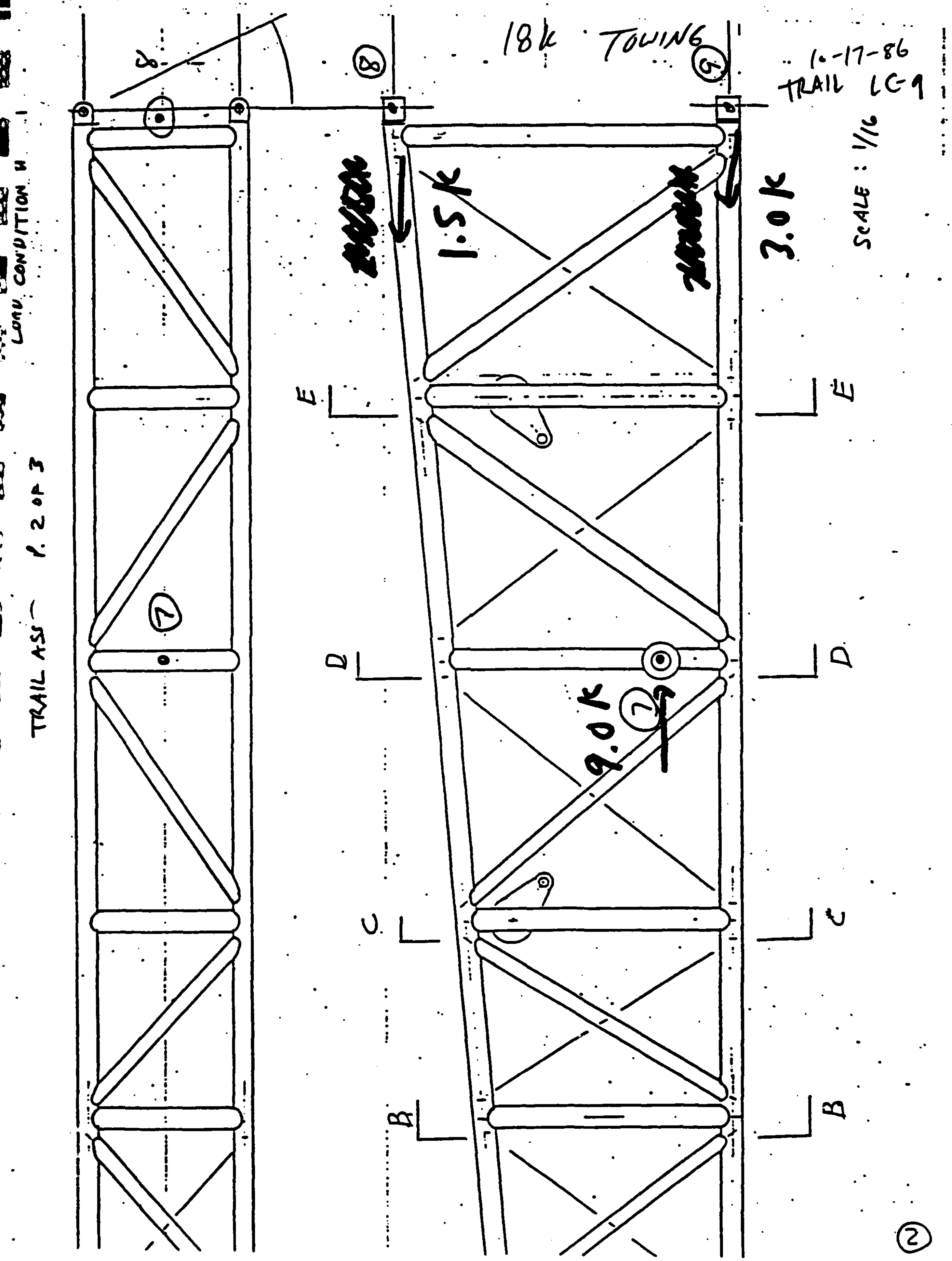
SCALE: 1/16

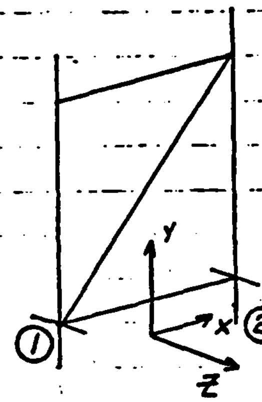
14

18k TOWING

1-17-86
TRAIL LG9

15





2. TRANSPORT - BUMP + SKID

FORCE	NODE 1	NODE 2
FX	-3700 lb	-3500 lb
FY	8600 lb	-16400 lb
FZ	3100 lb	-7600 lb
MX	0	0
MY	-9200 in-lb	-1400 in-lb
MZ	4900 in-lb	26,200 in-lb

3. TRANSPORT - 4.5G AIR DROP

FORCE	NODE 1	NODE 2
FX	-600 LB.	600 LB.
FY	-9800 LB.	-7700 LB.
FZ	100 LB.	-100 LB.
MX	0	0
MY	-22820 in-LB.	20900 in-lb
MZ	-27200 in-lb.	23800 in-lb

F. TRAVEL LOCK - TRAIL TO CRADLE

1. TRANSPORT - ±2100 LB. VERTICAL LOAD ON LINK AND TRIANGULAR BRACKET

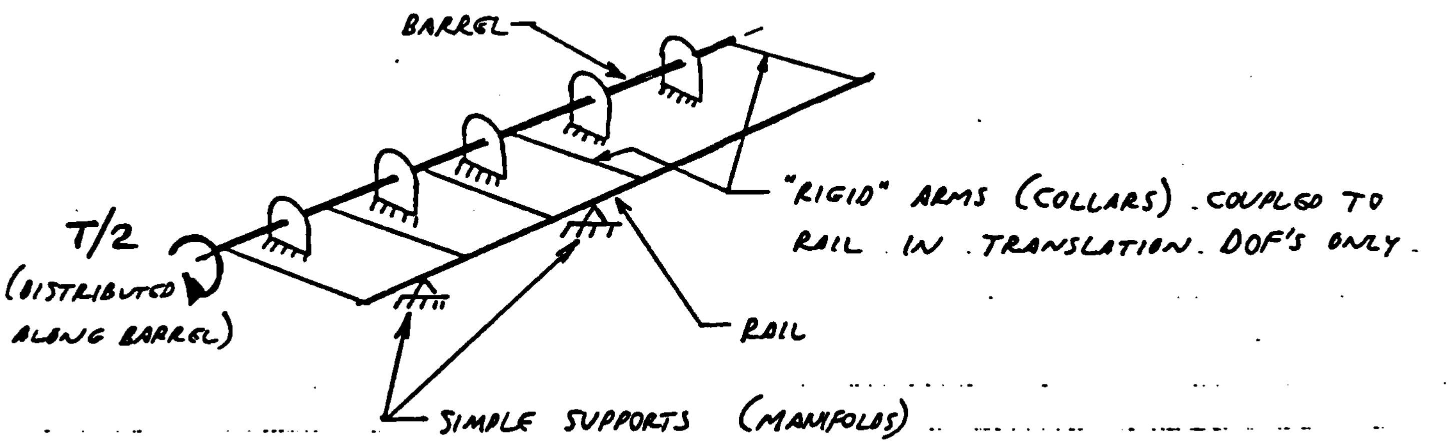
C. MUZZLE BRAKE

1. INTERNAL PRESSURE - 11,000 PSI. THREADED REGION OF BARREL AND BRAKE ANALYZED AS CONCENTRIC CYLINDERS.

2. THERMAL STRESS - INSIDE TEMPERATURE = +250°F
OUTSIDE " = -25°F

D. RAILS

1. RIFLING TORQUE - 48,000 FT-LB., COOK-OFF WITH BARREL/RAIL ASSEMBLY IN INTERMEDIATE POSITION. ACTUAL LOADING ON RAIL DETERMINED BY MODEL OF BARREL/RAIL SYSTEM:

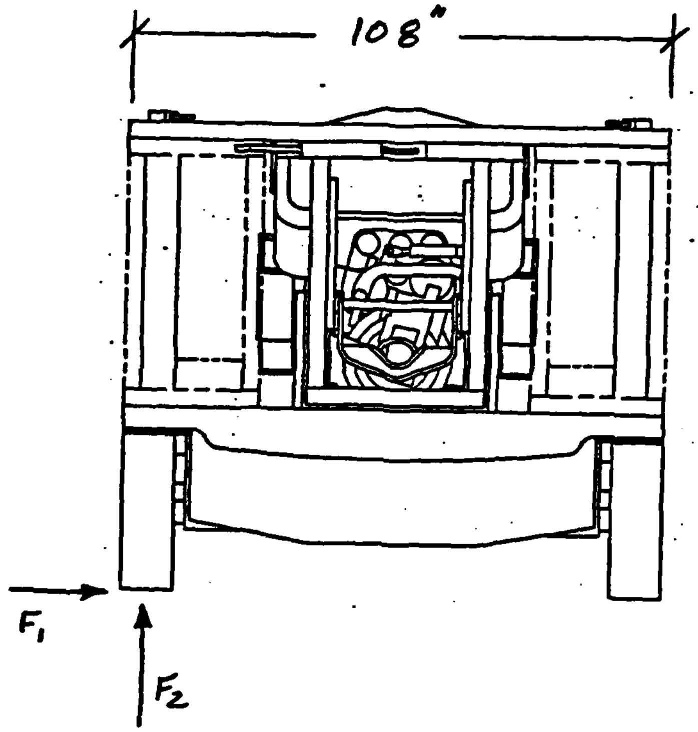


E. TRAIL BULKHEAD

1. CYLINDER LOADS - 20,000 LB. @ 32° - FRONT
25,000 LB. @ 8° - REAR
LOADS MAY OCCUR INDIVIDUALLY OR SIMULTANEOUSLY.

TRAIL L.C.-9 DSL
10-13-86

TRAVEL LOADING & ASSUMPTIONS



1. Lateral Load .8 g

$F_1 = .8\ (9) = 7.2$ Kip

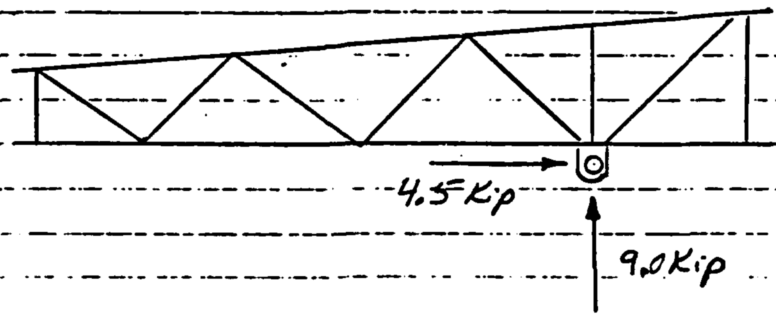
2. Vertical Load

$F_2 = 9$ Kip

Load is Taken By one side Simulateing a Roll over Condition.

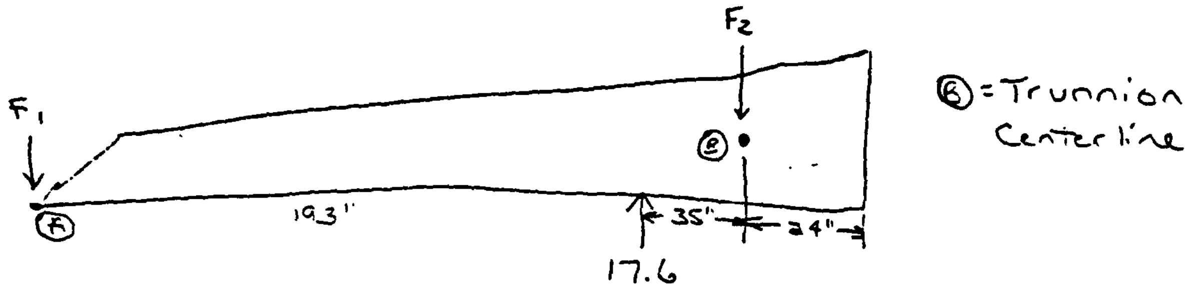
1.3 VERTICAL & FOR/AFT LOADS DUE TO BUMPS

Loads Per Trail



2/13/87

4.5 G Air ~~[illegible]~~ CRAFT

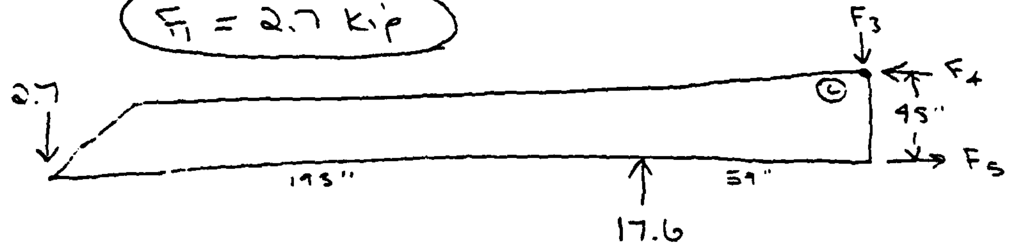


$\Sigma M_A = 193 \times 17.6 - 228 F_2 = 0$

$F_1 = 17.6 - 14.9 = 2.7$

$F_2 = 14.9$ kip

$F_1 = 2.7$ kip



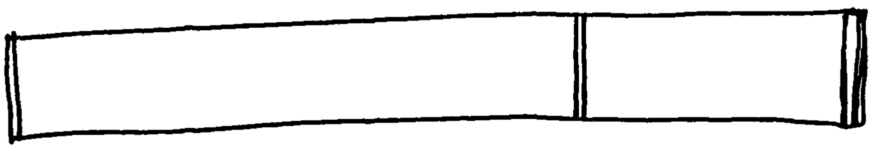
$F_3 = 17.6 - 2.7 = 14.9$ kip

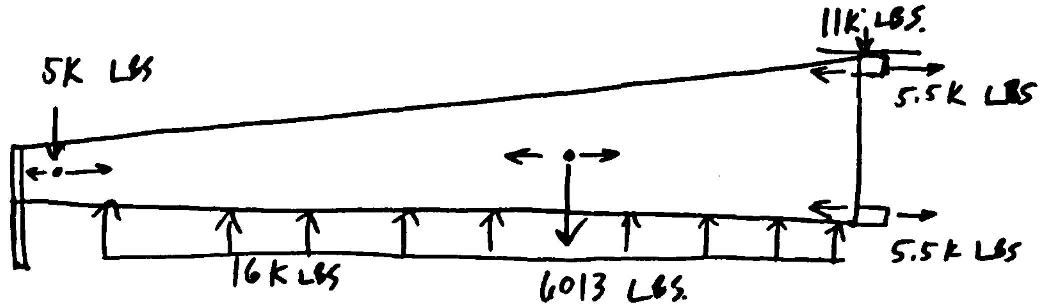
$\Sigma M_c = 2.7 \times 252 - 17.6 \times 59 + 45 F_5 = 0$

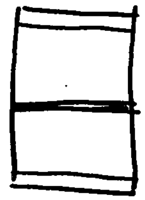
$F_5 = 7.5$ kip

$F_4 = 7.5$ kip

LOAD CONDITION # 19 - LAPES







LOADS ARE NOT CUMMULATIVE

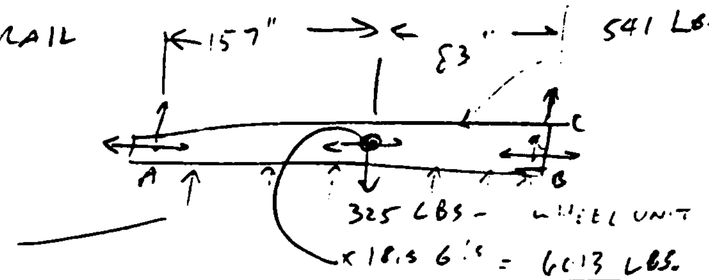
TRAIL LOADING

TRAIL LC-12 2

9/20/86

1 2 of 2

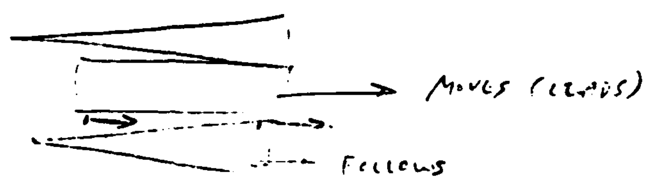
LVPD - TRAIL



= 16,040 LBS TRAIL

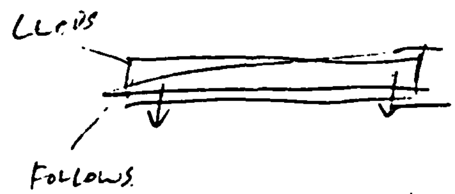
(541 + 325) = 867 LBS x 18.5 G's = 16,~~039.5~~ LBS HORIZ.

DISTRIBUTED AT A, B, C.



AND 16,040 LBS VERTICAL DISTR. ALONG BOTTOM.

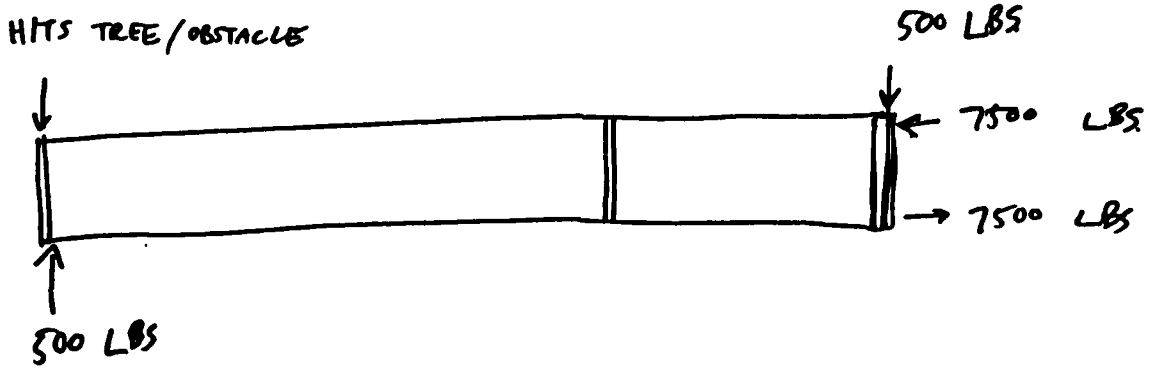
REST OF SYST
7268 LBS.
x 18.5
= 134,458 LBS

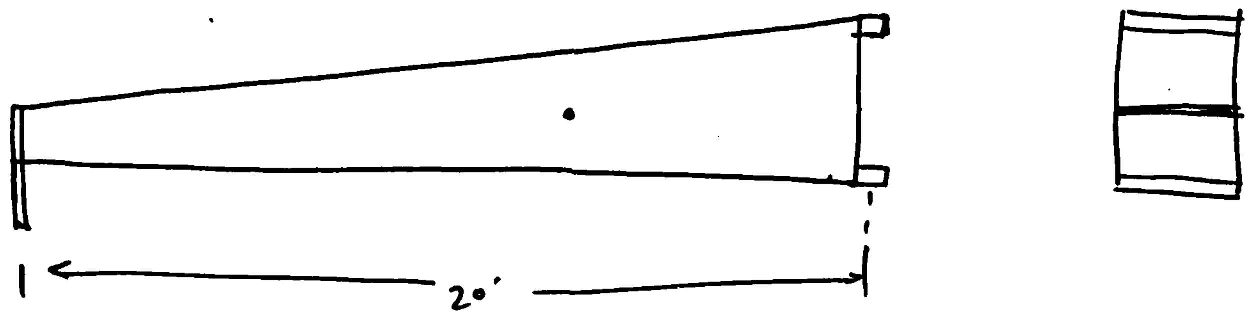


5K AT A + FWD BOTTOM

11,040 AT B, C + REAR BOTTOM

LOAD CONDITION # 22 - SPEEDSHIFT





TRAIL LOADING

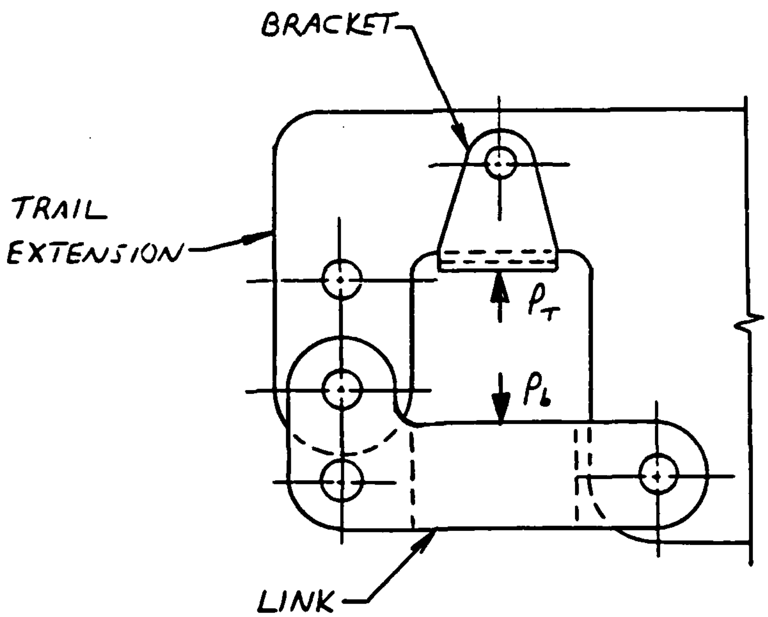
TRAILS LC-15
9/20/86

‾. TRAIL/CRADLE TRAVEL LOCK

The travel lock consists of three main components: the composite trail extension, a link that closes over a projection of the cradle and carries downward-directed loads, and a triangular bracket to prevent direct bearing on the composite material from upward-directed loads. Maximum load from transport is 2,100 lb. in either direction.

The "L" shaped link was analyzed as a rigid frame. Titanium was selected for weight considerations. The section used has a maximum combined stress (axial + bending) of 45,340 PSI. Direct bearing stress, assuming a contact width of 0.1 in., is -84,000 PSI. The resultant principal stress is -84,055 PSI, for a FS of 1.43. This falls within the desired range of 1.2-1.5.

The triangular bracket was checked for pin hole bearing, compression, and stability. Bearing stress in the hole is the limiting factor, with a bearing stress of 20,000 PSI (FS=1.50). Compression stress is low, and buckling of side plates is not significant.



TRAVEL LOCK GEOMETRY

PART NUMBER: 12585845, 12585847, Trail Bulkheads

DESCRIPTION: TRAIL BULKHEAD

STATUS:

Finished drawings of the current bulkhead (TDP, Dwgs. 12585845, 12585847) design have been created and are supported by a complete finite element analysis. A summary of this analysis can be found in the following pages of this section.

AUTHOR: Joe Fishbein

TRAIL BULKHEAD

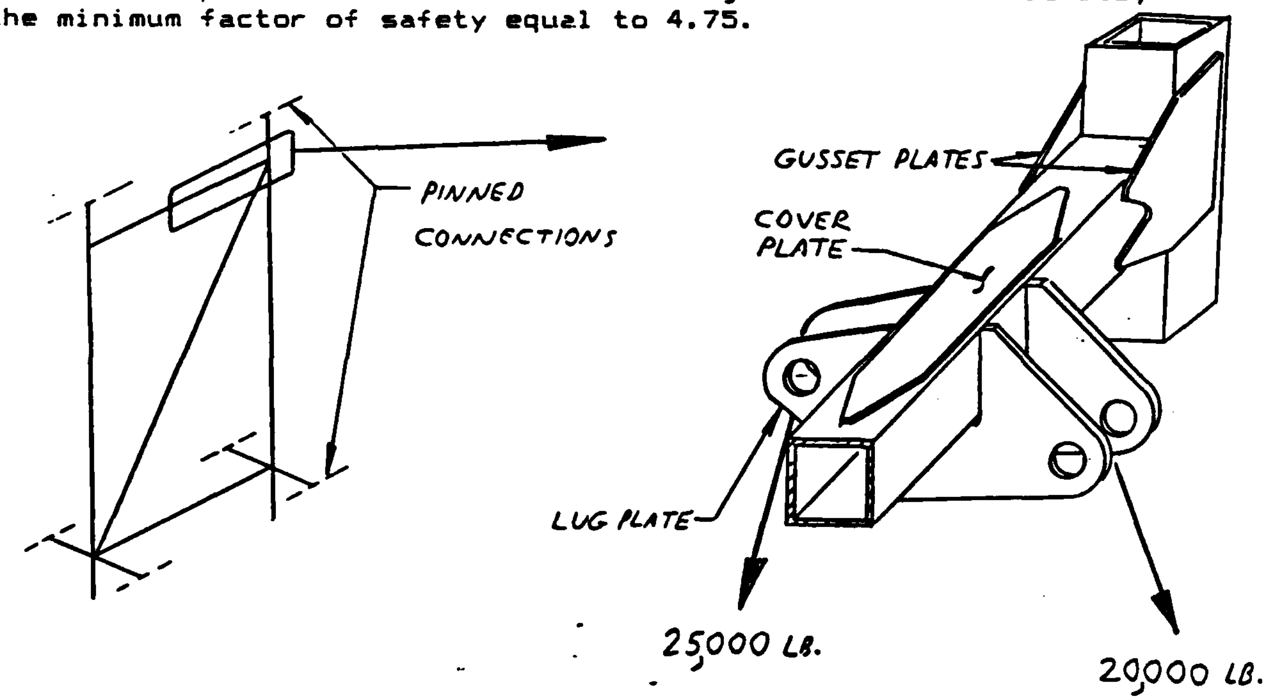
The trail bulkhead is a tubular truss that supports the wheel actuating cylinders. The main area of concern was the top cross member, where the cylinders attach.

A FEM of the bulkhead was used for the analysis. Loading of the top beam is from the front cylinder (20,000 lb. @ 32-deg.) and rear cylinder (25,000 lb. @ 8-deg.). These loads may act independently or simultaneously. The analysis showed that the section was inadequate to carry these loads. By adding cover plates to the top and bottom surfaces at the center, the maximum fiber stress is 62,574 PSI (FS=1.92), occurring when both cylinders are loaded. This stress will actually be less, since the load is divided between two lug plates, not a single central plate as was modeled. Gusset plates on the ends are also required to keep the weld size to a reasonable value.

The lug plates were sized based on net tensile area and shear tearout. Factor of Safety is greater than 2.0 for both factors.

The pin holding the cylinder to the lugs was also checked. The diameter of the pin (1.00 in.) was pre-determined by bearing selection. Likewise, the spacing between lugs was fixed by fabrication constraints. Thus, the pin has a very high bending stress (135,812 PSI for a pin with a 0.50 in. dia. hole for weight savings). Maraging steel (Grade 250, type III) gives a FS of 1.77.

Additional loads, seen during transport, were run on the model. These are applied to the bottom of the vertical members. Loads from towing (bump and skid) and air drop (4.5 G) were used. Resulting stresses are moderate, with the minimum factor of safety equal to 4.75.



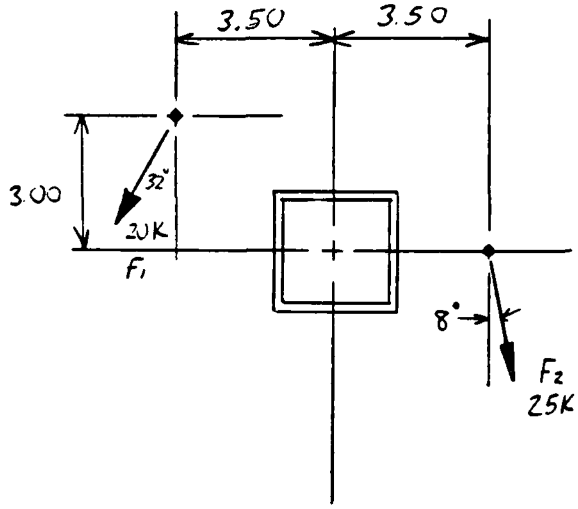
TOP BEAM DETAIL

FMC Northern Ordnance Division Minneapolis

APPLIED MECHANICS

Subject	Analyst	Project Number	EC. No.	Date
LTHD	JMF			3-9-87

RE-DESIGN - LOWER TOP BEAM 3.0 in



$$F_V = F_1 \cos 32° + F_2 \cos 8°$$

$$F_H = F_1 \sin 32° - F_2 \sin 8°$$

$$T = (F_1 \cos 32°)(3.5) + (F_1 \sin 32°)(3.0) - (F_2 \cos 8°)(3.50)$$

LC	F_1 (lb)	F_2 (lb)	F_V (lb)	F_H (lb)	T (in-lb)
1	20,000	0	16,961	10,598	91,159
2	0	25,000	24,757	-3,479	-86,648
3	20,000	25,000	41,718	7,119	4,510

Sheet ___ Of ___

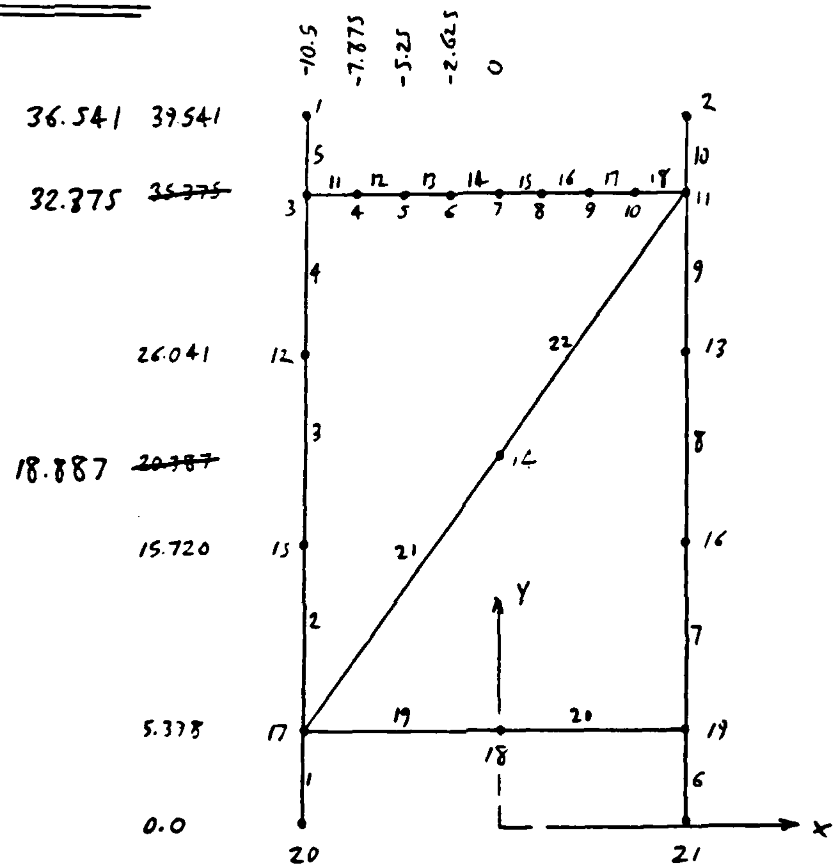
DA-649Oct86

FMC Northern Ordnance Division
Minneapolis

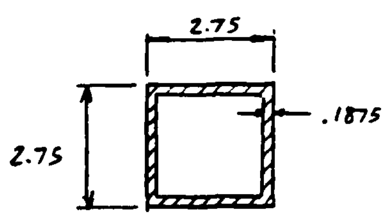
APPLIED MECHANICS

Subject	Analyst	
LTHD	JMA	
TRAIL BULKHEAD	Project Number	
	EC. No.	Date ~~2-7-87~~ 3-9-87

3/3/87 RE-DESIGN



MAT'L: TITANIUM 16.5×10^6, .165, 6.0E-6, .3
(E) (ρ) (α) (ν)



A : 1.9219 in^2
I : 2.1146 in^4
J : 3.1550 in^4

SUPPORTS: NODES 1,2,17,19 FIXED 12356

Sheet ___ Of ___

DA-649Oct86

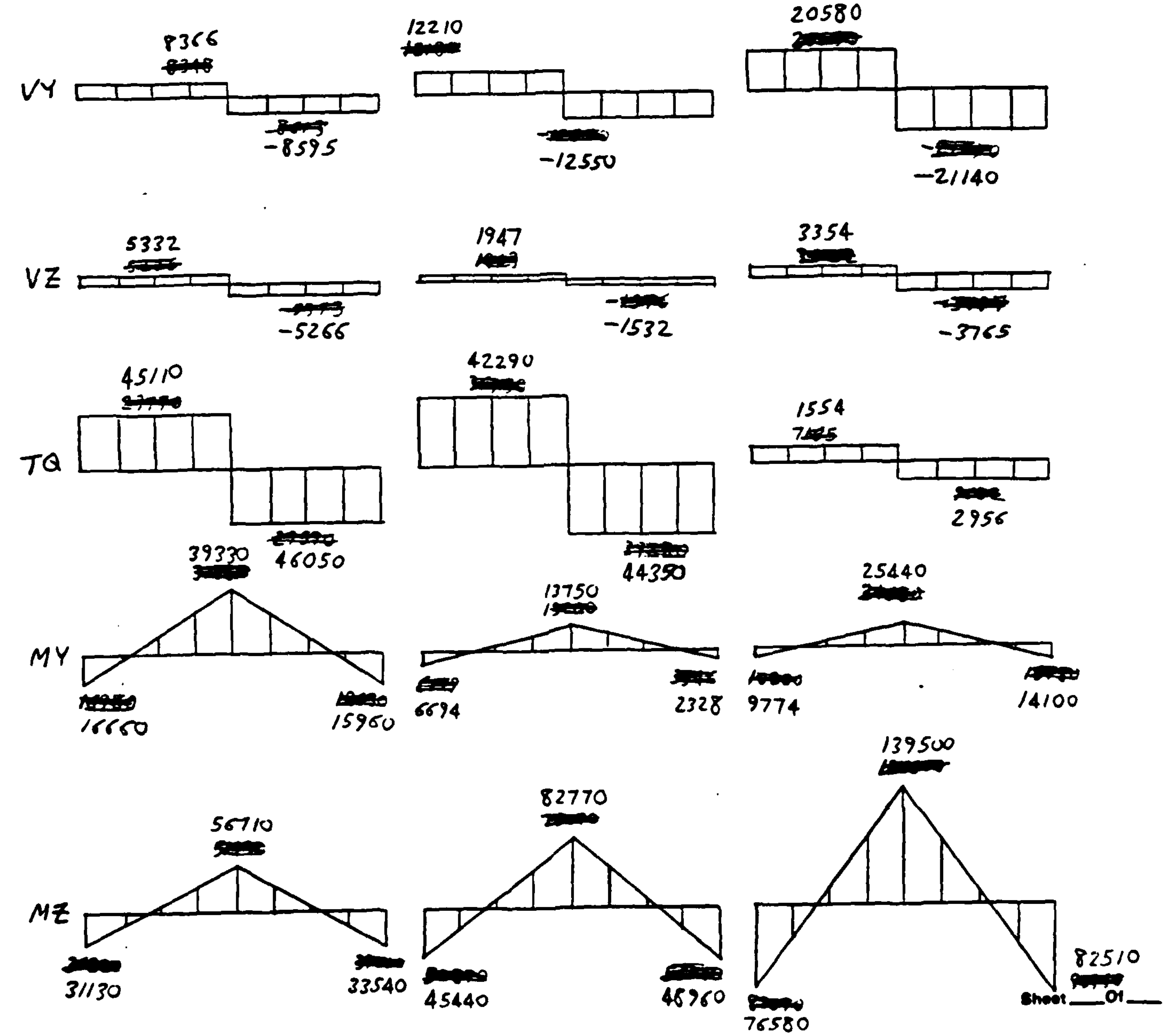
FMC Northern Ordnance Division
Minneapolis

APPLIED MECHANICS

Subject	Analyst	Project Number	EC. No.	Date
LTHD TRAIL BULKHEAD	JMF			~~2-6-87~~ 3-9-87

MEMBER LOADS 3/3/87 RE-DESIGN

	F1 ONLY	F2 ONLY	$F_1 + F_2$
AXIAL	2566 lb	3746 lb	6313 lb



Sheet ____ 01 ____

DA-6490-185

FMC Northern Ordnance Division
Minneapolis

APPLIED MECHANICS

Subject	Analyst	
LTHD	[illegible]	
	Project Number	
	EC. No.	Date 3-9-87

MAX BENDING + AXIAL - LC 3

MAX FIBER STRESS:

$$(LC\,3)\quad \sigma_{max} = \frac{6313\ lb}{3.1094\ in^2} + \frac{139{,}500\ in\cdot lb}{2.9471\ in^3} + \frac{25420\ in\cdot lb}{1.9438\ in^3} = 62{,}453\ psi$$

(121 psi LESS THAN PREVIOUS MODEL)

$$FS = \frac{120{,}000}{62453} = 1.92$$

MAX SHEAR STRESS

$$\tau_{max} = \frac{VY}{2(.188)(2.75)} + \frac{TQ\,(1.281)}{3.1550}$$

LC	VY	TQ	τ_{max}	$FS = \frac{.58 F_Y}{\tau_{max}}$	
1	8595	46050	27010	2.58	
2	12550	44350	30144	2.31	* OK
3	21140	2956	21645	3.22	

Sheet ___ Of ___

DA-649Oct86

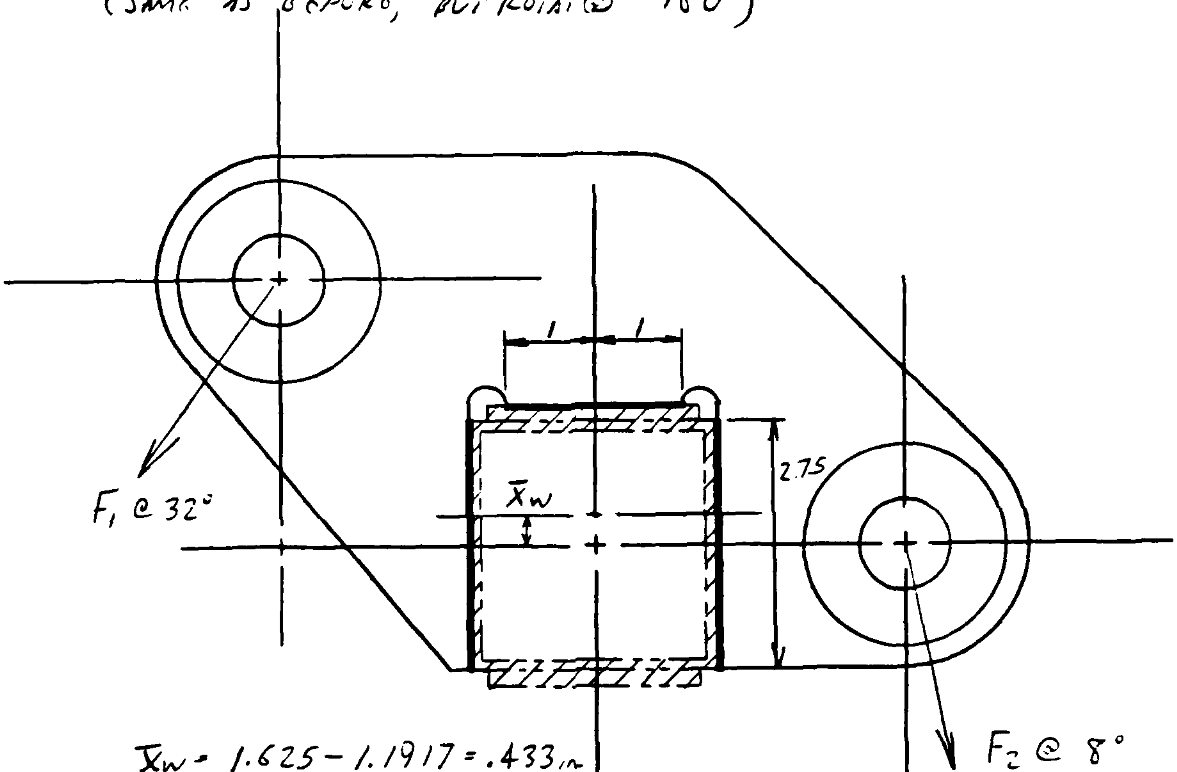
FMC Northern Ordnance Division
Minneapolis

APPLIED MECHANICS

Subject	Analyst	
LTHD	JMF	
	Project Number	
	EC. No.	Date 3-7-87

MODIFIED LUG GEOMETRY

(SAME AS BEFORE, BUT ROTATED 180°)



$\bar{X}_w = 1.625 - 1.1917 = .433 \text{ in}$
$A_w = 7.50 \text{ in}^2$
$J_w = 15.6383 \text{ in}^4$

$$T_w = (F_1 \cos 32°)(3.50) + (F_1 \sin 32°)(3.00 - \bar{x}_w) - (F_2 \cos 8°)(3.50) + (F_2 \sin 8°)(\bar{x}_w)$$

$$F_{wV} = F_1 \cos 32° + F_2 \cos 8°$$

$$F_{wH} = F_1 \sin 32° - F_2 \sin 8°$$

$$f_{wH} \left(\frac{F_{wH}}{A_w} + \frac{(T_w)(1.375 - \bar{x}_w)}{J_w} \right) \mp \left(\frac{F_{wV}}{A_w} \right)$$

$$f_{wV} \left(\frac{F_{wV}}{A_w} + \frac{(T_w)(1.375)}{J_w} \right) \mp \left(\frac{F_{wH}}{A_w} \right)$$

Sheet ___ Of ___

DA-649Oct85

FMC Northern Ordnance Division
Minneapolis

APPLIED MECHANICS

Subject	Analyst	Project Number	EC. No.	Date
LTHD	JMF			3·9·87

			LOADS			WELD LOADS (lb/in)	
LC	F_1 (lb)	F_2 (lb)	F_{wV} (lb)	F_{wH} (lb)	T_w (in-lb)	F_{wH}	F_{wV}
1	20000	—	16961	10598	86569	7003	9974
2	—	25000	24757	−3479	85142	6494	10797 *
3	20000	25000	41718	7119	1428	5658	5767

MAX FOR ONE LUG = (.6)(10797) = 6478 lb/in

MINIMUM $w = \dfrac{6.478 \text{ KSI}}{(.707)(36 \text{ KSI})} = .25$ in $\rightarrow$ 3/16 $w = .38$ OK

Sheet ____ Of ____

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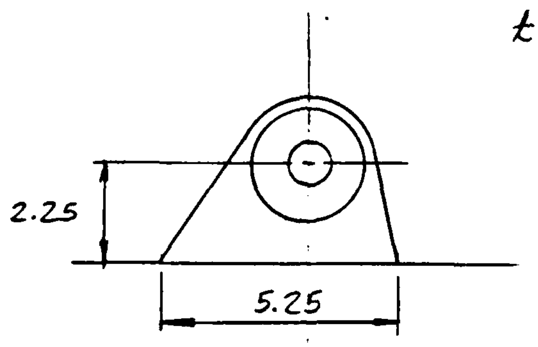
Minneapolis

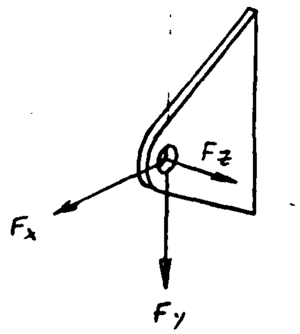
APPLIED MECHANICS

Subject	Analyst	
LTHD	JMF	
	Project Number	
	EC. No.	Date 3-10-87

BOTTOM LUG - SIDELOAD

$t = 3/16$ in





$$I_y = \frac{(5.25)(.1875)^3}{12} = .0029 \text{ in}^4$$

$$S_y = \frac{2 I_y}{t} = .0308 \text{ in}^3$$

$$M_{max} = 2.25 F_z$$

FOR $FS = 2.0$, MAX $\sigma_b = 60,000$ psi

$$\frac{2.25 F_z}{.0308} = 60,000 \text{ psi} \qquad F_z = 820 \text{ lb}$$

DA-649Oct86

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! NN      NN UUUUUUUUUU   333333    666666     555555     666666    2222222222 !
!                                                                              !
--------------------------------------------------------------------------------
                          FMC CORPORATION  S/N:800484
```

Job Information	
Project	: LTHD
Client	: D. Tollette
Job Name	: Trail Bulkhead
Remarks	: 3/3/87 Re-design
Engineer	: ______________/________ J. Fishbein
Chk'd by	: ______________/________
Appr'd by	: ______________/________
Comments	: FN = TRAILDIA.*


```
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========================= I M A G E S - 3 D ====================================
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CHECK GEOMETRY Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

MATERIAL PROPERTIES

Material No	Modulus of Elasticity	Weight Density	Coeff of Thermal Exp.	Poisson's Ratio	Shear Web Modulus
1	1.65000E+07	1.65000E-01	6.00000E-06	3.00E-01	0.00000E+00

NODE COORDINATES

Node	X-Coord.	Y-Coord.	Z-Coord.
1	-1.05000E+01	3.65410E+01	0.00000E+00
2	1.05000E+01	3.65410E+01	0.00000E+00
3	-1.05000E+01	3.23750E+01	0.00000E+00
4	-7.87500E+00	3.23750E+01	0.00000E+00
5	-5.25000E+00	3.23750E+01	0.00000E+00
6	-2.62500E+00	3.23750E+01	0.00000E+00
7	0.00000E+00	3.23750E+01	0.00000E+00
8	2.62500E+00	3.23750E+01	0.00000E+00
9	5.25000E+00	3.23750E+01	0.00000E+00
10	7.87500E+00	3.23750E+01	0.00000E+00
11	1.05000E+01	3.23750E+01	0.00000E+00
12	-1.05000E+01	2.60410E+01	0.00000E+00
13	1.05000E+01	2.60410E+01	0.00000E+00
14	0.00000E+00	1.88870E+01	0.00000E+00
15	-1.05000E+01	1.57200E+01	0.00000E+00
16	1.05000E+01	1.57200E+01	0.00000E+00
17	-1.05000E+01	5.39800E+00	0.00000E+00
18	0.00000E+00	5.39800E+00	0.00000E+00
19	1.05000E+01	5.39800E+00	0.00000E+00
20	-1.05000E+01	0.00000E+00	0.00000E+00
21	1.05000E+01	0.00000E+00	0.00000E+00
22	-1.05000E+01	5.39800E+00	-3.62500E+00
23	-1.05000E+01	5.39800E+00	3.62500E+00
24	1.05000E+01	5.39800E+00	-3.62500E+00
25	1.05000E+01	5.39800E+00	3.62500E+00

CHECK GEOMETRY Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

BEAM PROPERTIES

Multiplier = 1 (For AISC database properties only)

Prop No	X-Section Area	Moment of Inertia Iy	/ Iz	Torsional Const.- J
1	1.922E+00	2.115E+00	2.115E+00	3.155E+00
2	3.109E+00	2.673E+00	4.789E+00	3.155E+00
3	2.000E+00	4.170E-02	2.667E+00	1.667E-01

Prop No	Max. Fiber Dist Cy	/ Cz	Shear Shape Fact SSFy	/ SSFz	Ctors
1	1.38E+00	1.38E+00	2.27E+00	2.27E+00	1.38E+00
2	1.63E+00	1.38E+00	2.27E+00	2.27E+00	1.63E+00
3	2.00E+00	2.50E-01	1.18E+00	1.18E+00	2.00E+00

BEAM CONNECTIVITY

Beam No	Nodes From/	To/	Ref	Prop No	Mat No	Pincodes I / J	Length	Y Dir Cosines X	Y	Z	Beam Type
1	20	17	21	1	1		5.398E+00	1.00	0.00	0.00	Beam
2	17	15	21	1	1		1.032E+01	1.00	0.00	0.00	Beam
3	15	12	21	1	1		1.032E+01	1.00	0.00	0.00	Beam
4	12	3	21	1	1		6.334E+00	1.00	0.00	0.00	Beam
5	3	1	21	1	1		4.166E+00	1.00	0.00	0.00	Beam
6	21	19	20	1	1		5.398E+00	-1.00	0.00	0.00	Beam
7	19	16	20	1	1		1.032E+01	-1.00	0.00	0.00	Beam
8	16	13	20	1	1		1.032E+01	-1.00	0.00	0.00	Beam
9	13	11	20	1	1		6.334E+00	-1.00	0.00	0.00	Beam
10	11	2	20	1	1		4.166E+00	-1.00	0.00	0.00	Beam
11	3	4	1	1	1		2.625E+00	0.00	1.00	0.00	Beam
12	4	5	1	1	1		2.625E+00	0.00	1.00	0.00	Beam
13	5	6	1	1	1		2.625E+00	0.00	1.00	0.00	Beam
14	6	7	1	2	1		2.625E+00	0.00	1.00	0.00	Beam
15	7	8	1	2	1		2.625E+00	0.00	1.00	0.00	Beam
16	8	9	1	1	1		2.625E+00	0.00	1.00	0.00	Beam
17	9	10	1	1	1		2.625E+00	0.00	1.00	0.00	Beam
18	10	11	1	1	1		2.625E+00	0.00	1.00	0.00	Beam
19	17	18	1	1	1		1.050E+01	0.00	1.00	0.00	Beam
20	18	19	1	1	1		1.050E+01	0.00	1.00	0.00	Beam
21	17	14	1	1	1		1.709E+01	-0.79	0.61	0.00	Beam
22	14	11	1	1	1		1.709E+01	-0.79	0.61	0.00	Beam

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CHECK GEOMETRY Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Beam No	Nodes From/	To/Ref		Prop No	Mat No	Pincodes I / J	Length	Y Dir Cosines X	Y	Z	Beam Type
23	17	22	20	3	1		3.625E+00	0.00	-1.00	0.00	Beam
24	17	23	20	3	1		3.625E+00	0.00	-1.00	0.00	Beam
25	19	24	21	3	1		3.625E+00	0.00	-1.00	0.00	Beam
26	19	25	21	3	1		3.625E+00	0.00	-1.00	0.00	Beam

RESTRAINTS

Node No	Restraint Directions
1	X Y Z - RY RZ
2	X Y Z - RY RZ
22	X Y Z - - -
23	X Y Z - - -
24	X Y Z - - -
25	X Y Z - - -

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============== I M A G E S 3 D ==============

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RENUMBER NODES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Node Renumbering Cross Reference List

Was	Is	Was	Is	Was	Is
1	7	2	21	3	4
4	2	5	1	6	3
7	5	8	8	9	10
10	12	11	18	12	6
13	20	14	15	15	9
16	23	17	11	18	14
19	19	20	13	21	22
22	16	23	17	24	24
25	25				

Original Nodal Band 10
Final Nodal band 7

ASSEMBLE STIFFNESS MATRIX Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

STIFFNESS ASSEMBLY SUMMARY

Number of Node Points.................	25
Number of Truss and Beam Elements.....	26
Number of Plate Elements..............	0
Number of Spring Elements.............	0
Number of Nodes with Restraints.......	6
Number of Blocks in the Matrix........	1

BLOCK NUMBER 1

FORM Matrix
PACK Matrix
Size = 17720 Bytes
TRIANGULARIZE Matrix

Number of terms in the matrix.	2215
Largest column................	35
Minimum Diagonal Stiffness =	.1323593D+06
Maximum Diagonal Stiffness =	.7093601D+08

ASSEMBLE STIFFNESS MATRIX Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

C R O S S R E F E R E N C E L I S T

Is Node Verus Internal Equation Number

Is	TRANSLATION /			ROTATION		
Node	Eqn.	Eqn.	Eqn.	Eqn.	Eqn.	Eqn.
1	1	2	3	4	5	6
2	7	8	9	10	11	12
3	13	14	15	16	17	18
4	19	20	21	22	23	24
5	25	26	27	28	29	30
6	31	32	33	34	35	36
7				37		
8	38	39	40	41	42	43
9	44	45	46	47	48	49
10	50	51	52	53	54	55
11	56	57	58	59	60	61
12	62	63	64	65	66	67
13	68	69	70	71	72	73
14	74	75	76	77	78	79
15	80	81	82	83	84	85
16				86	87	88
17				89	90	91
18	92	93	94	95	96	97
19	98	99	100	101	102	103
20	104	105	106	107	108	109
21				110		
22	111	112	113	114	115	116
23	117	118	119	120	121	122
24				123	124	125
25				126	127	128

SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

L O A D C A S E 1

F1 Cylinder Load Only

CONCENTRATED LOADS

Node	Fx	Fy	Fz	Mx	My	Mz
7	.0000E+00	-.1696E+05	-.1060E+05	-.9116E+05	.0000E+00	.0000E+00

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=============== I M A G E S 3 D ===============

===

SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

L O A D C A S E 1

F1 Cylinder Load Only

APPLIED LOAD VECTOR

Node	Fx	Fy	Fz	Mx	My	Mz
7	.0000E+00	-.1696E+05	-.1060E+05	-.9116E+05	.0000E+00	.0000E+00

SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

L O A D C A S E 1

F1 Cylinder Load Only

DISPLACEMENTS

Node	Translations X	Translations Y	Translations Z	/	Rotations X	Rotations Y	Rotations Z
1	.0000E+00	.0000E+00	.0000E+00	/	-.2093E-02	.0000E+00	.0000E+00
2	.0000E+00	.0000E+00	.0000E+00	/	-.1626E-02	.0000E+00	.0000E+00
3	-.1060E-02	-.9981E-03	.5993E-02	/	-.3671E-02	.3005E-02	-.1890E-02
4	-.8473E-03	-.1240E-01	-.5684E-02	/	-.9586E-02	.3732E-02	-.3407E-02
5	-.6349E-03	-.2561E-01	-.1789E-01	/	-.1550E-01	.3406E-02	-.3271E-02
6	-.4224E-03	-.3630E-01	-.2785E-01	/	-.2141E-01	.2027E-02	-.1483E-02
7	-.2911E-03	-.4088E-01	-.3244E-01	/	-.2733E-01	.1023E-03	.3653E-04
8	-.1598E-03	-.3605E-01	-.2841E-01	/	-.2129E-01	-.1827E-02	.1546E-02
9	.5267E-04	-.2516E-01	-.1897E-01	/	-.1526E-01	-.3226E-02	.3266E-02
10	.2651E-03	-.1199E-01	-.7233E-02	/	-.9218E-02	-.3585E-02	.3288E-02
11	.4776E-03	-.9843E-03	.4083E-02	/	-.3181E-02	-.2904E-02	.1613E-02
12	-.7889E-02	-.8446E-03	.1854E-01	/	-.8620E-03	.2301E-02	-.5304E-03
13	.6687E-02	-.8257E-03	.1513E-01	/	-.7881E-03	-.2288E-02	.5320E-03
14	.5109E-02	-.4485E-02	.5874E-02	/	-.1040E-02	-.1792E-02	-.3938E-03
15	-.5758E-02	-.5945E-03	.1208E-01	/	.1222E-02	.1156E-02	.5299E-03
16	.5760E-02	-.5672E-03	.1012E-01	/	.1006E-02	-.1284E-02	-.4231E-03
17	-.7526E-04	-.3444E-03	.5695E-04	/	.2155E-03	.1012E-04	.1578E-03
18	.2936E-04	.1081E-02	-.7087E-03	/	.2032E-03	.3743E-04	.3249E-04
19	.1340E-03	-.3087E-03	.5294E-04	/	.1909E-03	-.2808E-03	-.3785E-03
20	.7766E-03	-.3444E-03	-.1106E-02	/	.2155E-03	.1012E-04	.1578E-03
21	-.1909E-02	-.3087E-03	-.9776E-03	/	.1909E-03	-.2808E-03	-.3785E-03
22	.0000E+00	.0000E+00	.0000E+00	/	.1220E-03	-.3554E-04	.1578E-03
23	.0000E+00	.0000E+00	.0000E+00	/	-.2533E-04	.2585E-04	.1578E-03
24	.0000E+00	.0000E+00	.0000E+00	/	.1089E-03	.1890E-03	-.3785E-03
25	.0000E+00	.0000E+00	.0000E+00	/	-.2321E-04	.7969E-04	-.3785E-03

SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

L O A D C A S E 2

F2 Cylinder Load Only

CONCENTRATED LOADS

Node	Fx	Fy	Fz	Mx	My	Mz
7	.0000E+00	-.2476E+05	.3479E+04	.8665E+05	.0000E+00	.0000E+00

SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

L O A D C A S E 2

F2 Cylinder Load Only

APPLIED LOAD VECTOR

Node	Fx	Fy	Fz	Mx	My	Mz
7	.0000E+00	-.2476E+05	.3479E+04	.8665E+05	.0000E+00	.0000E+00

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SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

L O A D C A S E 2

F2 Cylinder Load Only

DISPLACEMENTS

Node	Translations X	Translations Y	Translations Z	/	Rotations X	Rotations Y	Rotations Z
1	.0000E+00	.0000E+00	.0000E+00	/	.4247E-02	.0000E+00	.0000E+00
2	.0000E+00	.0000E+00	.0000E+00	/	.3246E-02	.0000E+00	.0000E+00
3	-.1547E-02	-.1457E-02	-.1620E-01	/	.5112E-02	-.1149E-02	-.2759E-02
4	-.1237E-02	-.1810E-01	-.1173E-01	/	.1066E-01	-.1461E-02	-.4972E-02
5	-.9267E-03	-.3738E-01	-.6961E-02	/	.1620E-01	-.1387E-02	-.4774E-02
6	-.6166E-03	-.5298E-01	-.2885E-02	/	.2175E-01	-.9294E-03	-.2164E-02
7	-.4249E-03	-.5967E-01	-.6655E-03	/	.2729E-01	-.2629E-03	.5332E-04
8	-.2332E-03	-.5261E-01	-.1408E-02	/	.2148E-01	.4362E-03	.2256E-02
9	.7688E-04	-.3673E-01	-.4130E-02	/	.1566E-01	.1017E-02	.4767E-02
10	.3870E-03	-.1750E-01	-.7980E-02	/	.9847E-02	.1296E-02	.4800E-02
11	.6971E-03	-.1437E-02	-.1216E-01	/	.4032E-02	.1272E-02	.2355E-02
12	-.1151E-01	-.1233E-02	-.3264E-01	/	.9454E-03	-.7786E-03	-.7742E-03
13	.9760E-02	-.1205E-02	-.2518E-01	/	.7583E-03	.9681E-03	.7766E-03
14	.7457E-02	-.6546E-02	-.1890E-01	/	.4133E-03	.1938E-02	-.5748E-03
15	-.8405E-02	-.8677E-03	-.1987E-01	/	-.2071E-02	-.1748E-03	.7735E-03
16	.8408E-02	-.8279E-03	-.1533E-01	/	-.1605E-02	.4732E-03	-.6176E-03
17	-.1099E-03	-.5027E-03	-.9828E-04	/	-.4109E-03	.4290E-03	.2303E-03
18	.4286E-04	.1578E-02	-.1270E-02	/	-.3489E-03	-.5733E-04	.4742E-04
19	.1956E-03	-.4505E-03	-.7531E-04	/	-.2868E-03	-.2187E-04	-.5525E-03
20	.1134E-02	-.5027E-03	.2120E-02	/	-.4109E-03	.4290E-03	.2303E-03
21	-.2787E-02	-.4505E-03	.1473E-02	/	-.2868E-03	-.2187E-04	-.5525E-03
22	.0000E+00	.0000E+00	.0000E+00	/	.1536E-04	-.2501E-03	.2303E-03
23	.0000E+00	.0000E+00	.0000E+00	/	-.1997E-03	-.1604E-03	.2303E-03
24	.0000E+00	.0000E+00	.0000E+00	/	.3205E-04	.9022E-04	-.5525E-03
25	.0000E+00	.0000E+00	.0000E+00	/	-.1608E-03	-.6930E-04	-.5525E-03

SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

L O A D C A S E 3

F1 + F2 Cylinder Loads

CONCENTRATED LOADS

Node	Fx	Fy	Fz	Mx	My	Mz
7	.0000E+00	-.4172E+05	-.7119E+04	.4510E+04	.0000E+00	.0000E+00

SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

L O A D C A S E 3

F1 + F2 Cylinder Loads

APPLIED LOAD VECTOR

Node	Fx	Fy	Fz	Mx	My	Mz
7	.0000E+00	-.4172E+05	-.7119E+04	.4510E+04	.0000E+00	.0000E+00

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================ I M A G E S 3 D ================

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SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

L O A D C A S E 3
F1 + F2 Cylinder Loads

DISPLACEMENTS

	Translations			Rotations		
Node	X	Y	Z	X	Y	Z
1	.0000E+00	.0000E+00	.0000E+00	.2719E-02	.0000E+00	.0000E+00
2	.0000E+00	.0000E+00	.0000E+00	.2052E-02	.0000E+00	.0000E+00
3	-.2607E-02	-.2455E-02	-.1247E-01	.2062E-02	.1829E-02	-.4650E-02
4	-.2084E-02	-.3050E-01	-.1958E-01	.2266E-02	.2234E-02	-.8379E-02
5	-.1562E-02	-.6299E-01	-.2689E-01	.2469E-02	.1976E-02	-.8045E-02
6	-.1039E-02	-.8928E-01	-.3265E-01	.2673E-02	.1055E-02	-.3646E-02
7	-.7160E-03	-.1006E+00	-.3490E-01	.2877E-02	-.1971E-03	.8986E-04
8	-.3930E-03	-.8866E-01	-.3152E-01	.2489E-02	-.1417E-02	.3802E-02
9	.1295E-03	-.6189E-01	-.2475E-01	.2101E-02	-.2215E-02	.8032E-02
10	.6521E-03	-.2949E-01	-.1686E-01	.1714E-02	-.2270E-02	.8088E-02
11	.1175E-02	-.2421E-02	-.9803E-02	.1326E-02	-.1581E-02	.3968E-02
12	-.1940E-01	-.2077E-02	-.1833E-01	.1888E-03	.1519E-02	-.1305E-02
13	.1645E-01	-.2031E-02	-.1327E-01	.4962E-04	-.1285E-02	.1309E-02
14	.1257E-01	-.1103E-01	-.1573E-01	-.6153E-03	.3614E-03	-.9687E-03
15	-.1416E-01	-.1462E-02	-.1032E-01	-.1114E-02	.1014E-02	.1303E-02
16	.1417E-01	-.1395E-02	-.7119E-02	-.8022E-03	-.8031E-03	-.1041E-02
17	-.1851E-03	-.8470E-03	-.5398E-04	-.2495E-03	.5079E-03	.3882E-03
18	.7222E-04	.2660E-02	-.2218E-02	-.1905E-03	-.2706E-04	.7991E-04
19	.3296E-03	-.7592E-03	-.3158E-04	-.1315E-03	-.3208E-03	-.9310E-03
20	.1910E-02	-.8470E-03	.1293E-02	-.2495E-03	.5079E-03	.3882E-03
21	-.4696E-02	-.7592E-03	.6784E-03	-.1315E-03	-.3208E-03	-.9310E-03
22	.0000E+00	.0000E+00	.0000E+00	.1253E-03	-.3185E-03	.3882E-03
23	.0000E+00	.0000E+00	.0000E+00	-.2372E-03	-.1675E-03	.3882E-03
24	.0000E+00	.0000E+00	.0000E+00	.1329E-03	.2879E-03	-.9310E-03
25	.0000E+00	.0000E+00	.0000E+00	-.1920E-03	.1907E-04	-.9310E-03

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 1:F1 Cylinder Load Only

BEAM LOADS AND/OR STRESSES

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
BEAM NO. 1							
LLoads	20	-.6151E-13	.1760E-10	-.6192E-11	-.4094E-15	.1668E-10	.4789E-10
LLoads	17	.6151E-13	-.1760E-10	.6192E-11	.4094E-15	.1652E-10	.4792E-10
Stress	20	.3200E-13	.2079E-10	-.7313E-11	.1784E-15	-.3114E-10	-.1084E-10
Stress	17	.3200E-13	.2079E-10	-.7313E-11	.1784E-15	.3116E-10	.1074E-10
BEAM NO. 2							
LLoads	17	.7684E+03	.4691E+03	.1012E+04	-.2222E+04	-.8627E+04	.3679E+04
LLoads	15	-.7684E+03	-.4691E+03	-.1012E+04	.2222E+04	-.1822E+04	.1163E+04
Stress	17	-.3998E+03	.5541E+03	.1196E+04	.9686E+03	-.2392E+04	.5610E+04
Stress	15	-.3998E+03	.5541E+03	.1196E+04	.9686E+03	.7565E+03	-.1185E+04
BEAM NO. 3							
LLoads	15	.7684E+03	.4691E+03	.1012E+04	-.2222E+04	.1822E+04	-.1163E+04
LLoads	12	-.7684E+03	-.4691E+03	-.1012E+04	.2222E+04	-.1227E+05	.6006E+04
Stress	15	-.3998E+03	.5541E+03	.1196E+04	.9686E+03	.7565E+03	-.1185E+04
Stress	12	-.3998E+03	.5541E+03	.1196E+04	.9686E+03	.3905E+04	-.7978E+04
BEAM NO. 4							
LLoads	12	.7684E+03	.4691E+03	.1012E+04	-.2222E+04	.1227E+05	-.6006E+04
LLoads	3	-.7684E+03	-.4691E+03	-.1012E+04	.2222E+04	-.1868E+05	.8977E+04
Stress	12	-.3998E+03	.5541E+03	.1196E+04	.9686E+03	.3905E+04	-.7978E+04
Stress	3	-.3998E+03	.5541E+03	.1196E+04	.9686E+03	.5837E+04	-.1215E+05
BEAM NO. 5							
LLoads	3	-.7597E+04	.3036E+04	.6345E+04	.1444E+05	-.2643E+05	.2216E+05
LLoads	1	.7597E+04	-.3036E+04	-.6345E+04	-.1444E+05	-.6268E-10	-.9509E+04
Stress	3	.3953E+04	.3585E+04	.7494E+04	-.6293E+04	-.1441E+05	.1719E+05
Stress	1	.3953E+04	.3585E+04	.7494E+04	-.6293E+04	-.6183E+04	-.4076E-10
BEAM NO. 6							
LLoads	21	.9492E-13	.1994E-10	.4502E-11	-.4186E-13	-.1185E-10	.5464E-10
LLoads	19	-.9492E-13	-.1994E-10	-.4502E-11	.4186E-13	-.1196E-10	.5507E-10
Stress	21	-.4939E-13	.2356E-10	.5317E-11	.1824E-13	-.3553E-10	.7708E-11
Stress	19	-.4939E-13	.2356E-10	.5317E-11	.1824E-13	.3581E-10	-.7775E-11
BEAM NO. 7							
LLoads	19	.7942E+03	.3274E+03	-.8546E+03	.1947E+04	.7166E+04	.1840E+04
LLoads	16	-.7942E+03	-.3274E+03	.8546E+03	-.1947E+04	.1655E+04	.1539E+04
Stress	19	-.4132E+03	.3867E+03	-.1009E+04	-.8484E+03	-.1197E+04	-.4660E+04
Stress	16	-.4132E+03	.3867E+03	-.1009E+04	-.8484E+03	.1001E+04	.1076E+04
BEAM NO. 8							
LLoads	16	.7942E+03	.3274E+03	-.8546E+03	.1947E+04	-.1655E+04	-.1539E+04
LLoads	13	-.7942E+03	-.3274E+03	.8546E+03	-.1947E+04	.1048E+05	.4919E+04
Stress	16	-.4132E+03	.3867E+03	-.1009E+04	-.8484E+03	.1001E+04	.1076E+04
Stress	13	-.4132E+03	.3867E+03	-.1009E+04	-.8484E+03	.3198E+04	.6812E+04

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 1:F1 Cylinder Load Only

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
				BEAM NO. 9			
LLoads	13	.7942E+03	.3274E+03	-.8546E+03	.1947E+04	-.1048E+05	-.4919E+04
LLoads	11	-.7942E+03	-.3274E+03	.8546E+03	-.1947E+04	.1589E+05	.6992E+04
Stress	13	-.4132E+03	.3867E+03	-.1009E+04	-.8484E+03	.3198E+04	.6812E+04
Stress	11	-.4132E+03	.3867E+03	-.1009E+04	-.8484E+03	.4547E+04	.1033E+05
				BEAM NO. 10			
LLoads	11	-.7492E+04	.3041E+04	-.6254E+04	-.1396E+05	.2606E+05	.1984E+05
LLoads	2	.7492E+04	-.3041E+04	.6254E+04	.1396E+05	-.6147E-09	-.7177E+04
Stress	11	.3898E+04	.3591E+04	-.7387E+04	.6082E+04	-.1290E+05	-.1694E+05
Stress	2	.3898E+04	.3591E+04	-.7387E+04	.6082E+04	-.4667E+04	-.3997E-09
				BEAM NO. 11			
LLoads	3	-.2566E+04	.8366E+04	.5332E+04	.4511E+05	-.1666E+05	.3113E+05
LLoads	4	.2566E+04	-.8366E+04	-.5332E+04	-.4511E+05	.2665E+04	-.9173E+04
Stress	3	.1335E+04	.9881E+04	.6298E+04	-.1966E+05	-.2024E+05	.1083E+05
Stress	4	.1335E+04	.9881E+04	.6298E+04	-.1966E+05	-.5965E+04	.1733E+04
				BEAM NO. 12			
LLoads	4	-.2566E+04	.8366E+04	.5332E+04	.4511E+05	-.2665E+04	.9173E+04
LLoads	5	.2566E+04	-.8366E+04	-.5332E+04	-.4511E+05	-.1133E+05	.1279E+05
Stress	4	.1335E+04	.9881E+04	.6298E+04	-.1966E+05	-.5965E+04	.1733E+04
Stress	5	.1335E+04	.9881E+04	.6298E+04	-.1966E+05	.8315E+04	-.7368E+04
				BEAM NO. 13			
LLoads	5	-.2566E+04	.8366E+04	.5332E+04	.4511E+05	.1133E+05	-.1279E+05
LLoads	6	.2566E+04	-.8366E+04	-.5332E+04	-.4511E+05	-.2533E+05	.3475E+05
Stress	5	.1335E+04	.9881E+04	.6298E+04	-.1966E+05	.8315E+04	-.7368E+04
Stress	6	.1335E+04	.9881E+04	.6298E+04	-.1966E+05	.2259E+05	-.1647E+05
				BEAM NO. 14			
LLoads	6	-.2566E+04	.8366E+04	.5332E+04	.4511E+05	.2533E+05	-.3475E+05
LLoads	7	.2566E+04	-.8366E+04	-.5332E+04	-.4511E+05	-.3933E+05	.5671E+05
Stress	6	.8254E+03	.6107E+04	.3893E+04	-.2324E+05	.1179E+05	-.1303E+05
Stress	7	.8254E+03	.6107E+04	.3893E+04	-.2324E+05	.1924E+05	-.2023E+05
				BEAM NO. 15			
LLoads	7	-.2566E+04	-.8595E+04	-.5266E+04	-.4605E+05	.3933E+05	-.5671E+05
LLoads	8	.2566E+04	.8595E+04	.5266E+04	.4605E+05	-.2550E+05	.3414E+05
Stress	7	.8254E+03	-.6275E+04	-.3844E+04	.2372E+05	.1924E+05	-.2023E+05
Stress	8	.8254E+03	-.6275E+04	-.3844E+04	.2372E+05	.1159E+05	-.1312E+05
				BEAM NO. 16			
LLoads	8	-.2566E+04	-.8595E+04	-.5266E+04	-.4605E+05	.2550E+05	-.3414E+05
LLoads	9	.2566E+04	.8595E+04	.5266E+04	.4605E+05	-.1168E+05	.1158E+05
Stress	8	.1335E+04	-.1015E+05	-.6219E+04	.2007E+05	.2220E+05	-.1658E+05
Stress	9	.1335E+04	-.1015E+05	-.6219E+04	.2007E+05	.7530E+04	-.7596E+04
				BEAM NO. 17			
LLoads	9	-.2566E+04	-.8595E+04	-.5266E+04	-.4605E+05	.1168E+05	-.1158E+05

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 1:F1 Cylinder Load Only

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
LLoads	10	.2566E+04	.8595E+04	.5266E+04	.4605E+05	.2141E+04	-.1098E+05
Stress	9	.1335E+04	-.1015E+05	-.6219E+04	.2007E+05	.7530E+04	-.7596E+04
Stress	10	.1335E+04	-.1015E+05	-.6219E+04	.2007E+05	-.7141E+04	.1392E+04
BEAM NO. 18							
LLoads	10	-.2566E+04	-.8595E+04	-.5266E+04	-.4605E+05	-.2141E+04	.1098E+05
LLoads	11	.2566E+04	.8595E+04	.5266E+04	.4605E+05	.1596E+05	-.3354E+05
Stress	10	.1335E+04	-.1015E+05	-.6219E+04	.2007E+05	-.7141E+04	.1392E+04
Stress	11	.1335E+04	-.1015E+05	-.6219E+04	.2007E+05	-.2181E+05	.1038E+05
BEAM NO. 19							
LLoads	17	-.3160E+03	-.9041E+02	.1094E+03	.2347E+02	-.6648E+03	-.5824E+02
LLoads	18	.3160E+03	.9041E+02	-.1094E+03	-.2347E+02	-.4834E+03	-.8911E+03
Stress	17	.1644E+03	-.1068E+03	.1292E+03	-.1023E+02	.3787E+02	.4323E+03
Stress	18	.1644E+03	-.1068E+03	.1292E+03	-.1023E+02	-.5794E+03	-.3143E+03
BEAM NO. 20							
LLoads	18	-.3160E+03	-.9041E+02	.1094E+03	.2347E+02	.4834E+03	.8911E+03
LLoads	19	.3160E+03	.9041E+02	-.1094E+03	-.2347E+02	-.1632E+04	-.1840E+04
Stress	18	.1644E+03	-.1068E+03	.1292E+03	-.1023E+02	-.5794E+03	-.3143E+03
Stress	19	.1644E+03	-.1068E+03	.1292E+03	-.1023E+02	-.1197E+04	-.1061E+04
BEAM NO. 21							
LLoads	17	.1536E+03	.3055E+03	-.1340E+03	.2569E+04	.1382E+04	.3737E+04
LLoads	14	-.1536E+03	-.3055E+03	.1340E+03	-.2569E+04	.9088E+03	.1485E+04
Stress	17	-.7993E+02	.3609E+03	-.1583E+03	-.1119E+04	-.2430E+04	-.8988E+03
Stress	14	-.7993E+02	.3609E+03	-.1583E+03	-.1119E+04	.9659E+03	.5909E+03
BEAM NO. 22							
LLoads	14	.1536E+03	.3055E+03	-.1340E+03	.2569E+04	-.9087E+03	-.1485E+04
LLoads	11	-.1536E+03	-.3055E+03	.1340E+03	-.2569E+04	.3200E+04	.6708E+04
Stress	14	-.7992E+02	.3609E+03	-.1583E+03	-.1119E+04	.9659E+03	.5909E+03
Stress	11	-.7992E+02	.3609E+03	-.1583E+03	-.1119E+04	.4362E+04	.2081E+04
BEAM NO. 23							
LLoads	17	-.5185E+03	-.6261E+03	.4781E+01	.2980E-14	-.1733E+02	-.2269E+04
LLoads	22	.5185E+03	.6261E+03	-.4781E+01	-.2980E-14	.1650E-12	-.6434E-10
Stress	17	.2592E+03	-.3694E+03	.2821E+01	-.3576E-13	.1702E+04	.1039E+03
Stress	22	.2592E+03	-.3694E+03	.2821E+01	-.3576E-13	-.4825E-10	.9890E-12
BEAM NO. 24							
LLoads	17	.5185E+03	.1613E+04	-.1647E+01	-.2980E-14	.5972E+01	.5847E+04
LLoads	23	-.5185E+03	-.1613E+04	.1647E+01	.2980E-14	.1085E-12	.1757E-10
Stress	17	-.2592E+03	.9516E+03	-.9720E+00	.3576E-13	-.4385E+04	-.3580E+02
Stress	23	-.2592E+03	.9516E+03	-.9720E+00	.3576E-13	.1317E-10	.6503E-12
BEAM NO. 25							
LLoads	19	-.4820E+03	-.5494E+03	-.4920E+02	-.1547E-14	.1783E+03	-.1991E+04
LLoads	24	.4820E+03	.5494E+03	.4920E+02	.1547E-14	-.1309E-11	.8728E-10
Stress	19	.2410E+03	-.3241E+03	-.2903E+02	.1856E-13	.1494E+04	-.1069E+04

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 1:F1 Cylinder Load Only

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
Stress	24	.2410E+03	-.3241E+03	-.2903E+02	.1856E-13	.6546E-10	-.7847E-11
BEAM NO. 26							
LLoads	19	.4820E+03	.1434E+04	-.3775E+02	.1547E-14	.1368E+03	.5198E+04
LLoads	25	-.4820E+03	-.1434E+04	.3775E+02	-.1547E-14	-.2326E-12	.5867E-11
Stress	19	-.2410E+03	.8460E+03	-.2227E+02	-.1856E-13	-.3898E+04	-.8204E+03
Stress	25	-.2410E+03	.8460E+03	-.2227E+02	-.1856E-13	.4400E-11	-.1394E-11

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 1:F1 Cylinder Load Only

MAXIMUM STRESS SUMMARY FOR BEAMS/TRUSSES
WITHIN SPECIFIED RANGE 1- 26

Maximum (absolute) Stress = .2372E+05 at BEAM 15

Beam	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
15	.8254E+03	-.6275E+04	-.3844E+04	.2372E+05	.1924E+05	-.2023E+05

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SOLVE REACTIONS Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 1:F1 Cylinder Load Only

REACTIONS

Node	Fx	Fy	Fz	Mx	My	Mz
1	-.3036E+04	.7597E+04	.6345E+04	.0000E+00	-.1444E+05	.9509E+04
2	.3041E+04	.7492E+04	.6254E+04	.0000E+00	.1396E+05	-.7177E+04
22	.4781E+01	-.6261E+03	-.5185E+03	.0000E+00	.0000E+00	.0000E+00
23	.1647E+01	.1613E+04	-.5185E+03	.0000E+00	.0000E+00	.0000E+00
24	-.4920E+02	-.5494E+03	-.4820E+03	.0000E+00	.0000E+00	.0000E+00
25	.3775E+02	.1434E+04	-.4820E+03	.0000E+00	.0000E+00	.0000E+00

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 2:F2 Cylinder Load Only

BEAM LOADS AND/OR STRESSES

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
				BEAM NO. 1			
LLoads	20	.1465E-12	-.1962E-10	.3477E-11	-.1665E-13	-.7401E-10	-.5295E-10
LLoads	17	-.1465E-12	.1962E-10	-.3477E-11	.1665E-13	.5573E-10	-.5312E-10
Stress	20	-.7625E-13	-.2317E-10	.4107E-11	.7258E-14	.3443E-10	.4812E-10
Stress	17	-.7625E-13	-.2317E-10	.4107E-11	.7258E-14	-.3454E-10	.3624E-10
				BEAM NO. 2			
LLoads	17	.1122E+04	.6848E+03	-.1532E+04	.1171E+04	.1352E+05	.5370E+04
LLoads	15	-.1122E+04	-.6848E+03	.1532E+04	-.1171E+04	.2293E+04	.1698E+04
Stress	17	-.5836E+03	.8088E+03	-.1809E+04	-.5105E+03	-.3492E+04	-.8788E+04
Stress	15	-.5836E+03	.8088E+03	-.1809E+04	-.5105E+03	.1104E+04	.1491E+04
				BEAM NO. 3			
LLoads	15	.1122E+04	.6848E+03	-.1532E+04	.1171E+04	-.2293E+04	-.1698E+04
LLoads	12	-.1122E+04	-.6848E+03	.1532E+04	-.1171E+04	.1810E+05	.8766E+04
Stress	15	-.5836E+03	.8088E+03	-.1809E+04	-.5105E+03	.1104E+04	.1491E+04
Stress	12	-.5836E+03	.8088E+03	-.1809E+04	-.5105E+03	.5700E+04	.1177E+05
				BEAM NO. 4			
LLoads	12	.1122E+04	.6848E+03	-.1532E+04	.1171E+04	-.1810E+05	-.8766E+04
LLoads	3	-.1122E+04	-.6848E+03	.1532E+04	-.1171E+04	.2780E+05	.1310E+05
Stress	12	-.5836E+03	.8088E+03	-.1809E+04	-.5105E+03	.5700E+04	.1177E+05
Stress	3	-.5836E+03	.8088E+03	-.1809E+04	-.5105E+03	.8520E+04	.1808E+05
				BEAM NO. 5			
LLoads	3	-.1109E+05	.4431E+04	-.3479E+04	-.5523E+04	.1449E+05	.3234E+05
LLoads	1	.1109E+05	-.4431E+04	.3479E+04	.5523E+04	-.3201E-09	-.1388E+05
Stress	3	.5770E+04	.5233E+04	-.4109E+04	.2407E+04	-.2103E+05	-.9424E+04
Stress	1	.5770E+04	.5233E+04	-.4109E+04	.2407E+04	-.9025E+04	-.2081E-09
				BEAM NO. 6			
LLoads	21	.2023E-12	-.4219E-10	.5202E-11	.2498E-15	-.1450E-10	-.1131E-09
LLoads	19	-.2023E-12	.4219E-10	-.5202E-11	-.2498E-15	-.1429E-10	-.1130E-09
Stress	21	-.1053E-12	-.4983E-10	.6144E-11	-.1089E-15	.7357E-10	.9429E-11
Stress	19	-.1053E-12	-.4983E-10	.6144E-11	-.1089E-15	-.7346E-10	-.9289E-11
				BEAM NO. 7			
LLoads	19	.1159E+04	.4779E+03	.1206E+04	-.9602E+03	-.1068E+05	.2686E+04
LLoads	16	-.1159E+04	-.4779E+03	-.1206E+04	.9602E+03	-.1767E+04	.2247E+04
Stress	19	-.6032E+03	.5645E+03	.1425E+04	.4185E+03	-.1747E+04	.6946E+04
Stress	16	-.6032E+03	.5645E+03	.1425E+04	.4185E+03	.1461E+04	-.1149E+04
				BEAM NO. 8			
LLoads	16	.1159E+04	.4779E+03	.1206E+04	-.9602E+03	.1767E+04	-.2247E+04
LLoads	13	-.1159E+04	-.4779E+03	-.1206E+04	.9602E+03	-.1421E+05	.7179E+04
Stress	16	-.6032E+03	.5645E+03	.1425E+04	.4185E+03	.1461E+04	-.1149E+04
Stress	13	-.6032E+03	.5645E+03	.1425E+04	.4185E+03	.4668E+04	-.9243E+04

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 2:F2 Cylinder Load Only

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
				BEAM NO. 9			
LLoads	13	.1159E+04	.4779E+03	.1206E+04	-.9602E+03	.1421E+05	-.7179E+04
LLoads	11	-.1159E+04	-.4779E+03	-.1206E+04	.9602E+03	-.2185E+05	.1021E+05
Stress	13	-.6032E+03	.5645E+03	.1425E+04	.4185E+03	.4668E+04	-.9243E+04
Stress	11	-.6032E+03	.5645E+03	.1425E+04	.4185E+03	.6637E+04	-.1421E+05
				BEAM NO. 10			
LLoads	11	-.1094E+05	.4438E+04	.3161E+04	.6113E+04	-.1317E+05	.2897E+05
LLoads	2	.1094E+05	-.4438E+04	-.3161E+04	-.6113E+04	.2666E-09	-.1048E+05
Stress	11	.5690E+04	.5242E+04	.3733E+04	-.2664E+04	-.1883E+05	.8562E+04
Stress	2	.5690E+04	.5242E+04	.3733E+04	-.2664E+04	-.6812E+04	.1734E-09
				BEAM NO. 11			
LLoads	3	-.3746E+04	.1221E+05	-.1947E+04	-.4229E+05	.6694E+04	.4544E+05
LLoads	4	.3746E+04	-.1221E+05	.1947E+04	.4229E+05	-.1582E+04	-.1339E+05
Stress	3	.1949E+04	.1442E+05	-.2300E+04	.1843E+05	-.2955E+05	-.4353E+04
Stress	4	.1949E+04	.1442E+05	-.2300E+04	.1843E+05	-.8706E+04	-.1029E+04
				BEAM NO. 12			
LLoads	4	-.3746E+04	.1221E+05	-.1947E+04	-.4229E+05	.1582E+04	.1339E+05
LLoads	5	.3746E+04	-.1221E+05	.1947E+04	.4229E+05	.3530E+04	.1866E+05
Stress	4	.1949E+04	.1442E+05	-.2300E+04	.1843E+05	-.8706E+04	-.1029E+04
Stress	5	.1949E+04	.1442E+05	-.2300E+04	.1843E+05	.1214E+05	.2295E+04
				BEAM NO. 13			
LLoads	5	-.3746E+04	.1221E+05	-.1947E+04	-.4229E+05	-.3530E+04	-.1866E+05
LLoads	6	.3746E+04	-.1221E+05	.1947E+04	.4229E+05	.8642E+04	.5072E+05
Stress	5	.1949E+04	.1442E+05	-.2300E+04	.1843E+05	.1214E+05	.2295E+04
Stress	6	.1949E+04	.1442E+05	-.2300E+04	.1843E+05	.3298E+05	.5619E+04
				BEAM NO. 14			
LLoads	6	-.3746E+04	.1221E+05	-.1947E+04	-.4229E+05	-.8642E+04	-.5072E+05
LLoads	7	.3746E+04	-.1221E+05	.1947E+04	.4229E+05	.1375E+05	.8277E+05
Stress	6	.1205E+04	.8914E+04	-.1422E+04	.2178E+05	.1721E+05	.4446E+04
Stress	7	.1205E+04	.8914E+04	-.1422E+04	.2178E+05	.2809E+05	.7076E+04
				BEAM NO. 15			
LLoads	7	-.3746E+04	-.1255E+05	.1532E+04	.4435E+05	-.1375E+05	-.8277E+05
LLoads	8	.3746E+04	.1255E+05	-.1532E+04	-.4435E+05	.9733E+04	.4984E+05
Stress	7	.1205E+04	-.9159E+04	.1118E+04	-.2284E+05	.2809E+05	.7076E+04
Stress	8	.1205E+04	-.9159E+04	.1118E+04	-.2284E+05	.1691E+05	.5007E+04
				BEAM NO. 16			
LLoads	8	-.3746E+04	-.1255E+05	.1532E+04	.4435E+05	-.9733E+04	-.4984E+05
LLoads	9	.3746E+04	.1255E+05	-.1532E+04	-.4435E+05	.5713E+04	.1690E+05
Stress	8	.1949E+04	-.1482E+05	.1809E+04	-.1933E+05	.3241E+05	.6329E+04
Stress	9	.1949E+04	-.1482E+05	.1809E+04	-.1933E+05	.1099E+05	.3715E+04
				BEAM NO. 17			
LLoads	9	-.3746E+04	-.1255E+05	.1532E+04	.4435E+05	-.5713E+04	-.1690E+05

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 2:F2 Cylinder Load Only

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
LLoads	10	.3746E+04	.1255E+05	-.1532E+04	-.4435E+05	.1693E+04	-.1603E+05
Stress	9	.1949E+04	-.1482E+05	.1809E+04	-.1933E+05	.1099E+05	.3715E+04
Stress	10	.1949E+04	-.1482E+05	.1809E+04	-.1933E+05	-.1042E+05	.1101E+04
BEAM NO. 18							
LLoads	10	-.3746E+04	-.1255E+05	.1532E+04	.4435E+05	-.1693E+04	.1603E+05
LLoads	11	.3746E+04	.1255E+05	-.1532E+04	-.4435E+05	-.2328E+04	-.4896E+05
Stress	10	.1949E+04	-.1482E+05	.1809E+04	-.1933E+05	-.1042E+05	.1101E+04
Stress	11	.1949E+04	-.1482E+05	.1809E+04	-.1933E+05	-.3184E+05	-.1514E+04
BEAM NO. 19							
LLoads	17	-.4612E+03	-.1320E+03	-.1651E+03	-.1183E+03	.2483E+04	-.8501E+02
LLoads	18	.4612E+03	.1320E+03	.1651E+03	.1183E+03	-.7491E+03	-.1301E+04
Stress	17	.2400E+03	-.1559E+03	-.1950E+03	.5157E+02	.5528E+02	-.1615E+04
Stress	18	.2400E+03	-.1559E+03	-.1950E+03	.5157E+02	-.8458E+03	-.4871E+03
BEAM NO. 20							
LLoads	18	-.4612E+03	-.1320E+03	-.1651E+03	-.1183E+03	.7491E+03	.1301E+04
LLoads	19	.4612E+03	.1320E+03	.1651E+03	.1183E+03	.9848E+03	-.2686E+04
Stress	18	.2400E+03	-.1559E+03	-.1950E+03	.5157E+02	-.8458E+03	-.4871E+03
Stress	19	.2400E+03	-.1559E+03	-.1950E+03	.5157E+02	-.1747E+04	.6403E+03
BEAM NO. 21							
LLoads	17	.2242E+03	.4460E+03	.4229E+03	-.1988E+04	-.4179E+04	.5455E+04
LLoads	14	-.2242E+03	-.4460E+03	-.4229E+03	.1988E+04	-.3050E+04	.2168E+04
Stress	17	-.1167E+03	.5267E+03	.4995E+03	.8664E+03	-.3547E+04	.2718E+04
Stress	14	-.1167E+03	.5267E+03	.4995E+03	.8664E+03	.1410E+04	-.1983E+04
BEAM NO. 22							
LLoads	14	.2242E+03	.4460E+03	.4229E+03	-.1988E+04	.3050E+04	-.2168E+04
LLoads	11	-.2242E+03	-.4460E+03	-.4229E+03	.1988E+04	-.1028E+05	.9791E+04
Stress	14	-.1167E+03	.5268E+03	.4995E+03	.8664E+03	.1410E+04	-.1983E+04
Stress	11	-.1167E+03	.5268E+03	.4995E+03	.8664E+03	.6367E+04	-.6684E+04
BEAM NO. 23							
LLoads	17	.8947E+03	.2855E+04	.7111E+02	.6259E-14	-.2578E+03	.1035E+05
LLoads	22	-.8947E+03	-.2855E+04	-.7111E+02	-.6259E-14	.3416E-11	.8368E-11
Stress	17	-.4473E+03	.1684E+04	.4196E+02	-.7509E-13	-.7761E+04	.1545E+04
Stress	22	-.4473E+03	.1684E+04	.4196E+02	-.7509E-13	.6276E-11	.2048E-10
BEAM NO. 24							
LLoads	17	-.8947E+03	-.1414E+04	.6173E+02	-.6259E-14	-.2238E+03	-.5126E+04
LLoads	23	.8947E+03	.1414E+04	-.6173E+02	.6259E-14	.9062E-12	-.4787E-11
Stress	17	.4473E+03	-.8343E+03	.3642E+02	.7509E-13	.3845E+04	.1342E+04
Stress	23	.4473E+03	-.8343E+03	.3642E+02	.7509E-13	-.3590E-11	.5433E-11
BEAM NO. 25							
LLoads	19	.6856E+03	.2135E+04	-.1174E+02	-.1249E-14	.4255E+02	.7740E+04
LLoads	24	-.6856E+03	-.2135E+04	.1174E+02	.1249E-14	.3979E-12	-.2165E-10
Stress	19	-.3428E+03	.1260E+04	-.6926E+01	.1499E-13	-.5805E+04	-.2551E+03

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 2:F2 Cylinder Load Only

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
Stress	24	-.3428E+03	.1260E+04	-.6926E+01	.1499E-13	-.1623E-10	.2386E-11
BEAM NO. 26							
LLoads	19	-.6856E+03	-.8441E+03	.4967E+01	.1249E-14	-.1800E+02	-.3060E+04
LLoads	25	.6856E+03	.8441E+03	-.4967E+01	-.1249E-14	-.9332E-12	.1126E-09
Stress	19	.3428E+03	-.4980E+03	.2930E+01	-.1499E-13	.2295E+04	.1079E+03
Stress	25	.3428E+03	-.4980E+03	.2930E+01	-.1499E-13	.8447E-10	-.5595E-11

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 2:F2 Cylinder Load Only

MAXIMUM STRESS SUMMARY FOR BEAMS/TRUSSES
WITHIN SPECIFIED RANGE 1- 26

Maximum (absolute) Stress = .3298E+05 at BEAM 13

Beam	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
13	.1949E+04	.1442E+05	-.2300E+04	.1843E+05	.3298E+05	.5619E+04

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SOLVE REACTIONS Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 2:F2 Cylinder Load Only

REACTIONS

Node	Fx	Fy	Fz	Mx	My	Mz
1	-.4431E+04	.1109E+05	-.3479E+04	.0000E+00	.5523E+04	.1388E+05
2	.4438E+04	.1094E+05	-.3161E+04	.0000E+00	-.6113E+04	-.1048E+05
22	.7111E+02	.2855E+04	.8947E+03	.0000E+00	.0000E+00	.0000E+00
23	-.6173E+02	-.1414E+04	.8947E+03	.0000E+00	.0000E+00	.0000E+00
24	-.1174E+02	.2135E+04	.6856E+03	.0000E+00	.0000E+00	.0000E+00
25	-.4967E+01	-.8441E+03	.6856E+03	.0000E+00	.0000E+00	.0000E+00

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 3:F1 + F2 Cylinder Loads

BEAM LOADS AND/OR STRESSES

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
				BEAM NO. 1			
LLoads	20	.3122E-12	-.2442E-10	.8651E-11	.5962E-13	-.2320E-10	-.6535E-10
LLoads	17	-.3122E-12	.2442E-10	-.8651E-11	-.5962E-13	-.2303E-10	-.6537E-10
Stress	20	-.1624E-12	-.2884E-10	.1022E-10	-.2598E-13	.4250E-10	.1509E-10
Stress	17	-.1624E-12	-.2884E-10	.1022E-10	-.2598E-13	-.4251E-10	-.1498E-10
				BEAM NO. 2			
LLoads	17	.1890E+04	.1154E+04	-.7100E+03	-.9809E+03	.6588E+04	.9049E+04
LLoads	15	-.1890E+04	-.1154E+04	.7100E+03	.9809E+03	.7411E+03	.2862E+04
Stress	17	-.9834E+03	.1363E+04	-.8386E+03	.4275E+03	-.5884E+04	-.4284E+04
Stress	15	-.9834E+03	.1363E+04	-.8386E+03	.4275E+03	.1861E+04	.4819E+03
				BEAM NO. 3			
LLoads	15	.1890E+04	.1154E+04	-.7100E+03	-.9809E+03	-.7411E+03	-.2862E+04
LLoads	12	-.1890E+04	-.1154E+04	.7100E+03	.9809E+03	.8069E+04	.1477E+05
Stress	15	-.9834E+03	.1363E+04	-.8386E+03	.4275E+03	.1861E+04	.4819E+03
Stress	12	-.9834E+03	.1363E+04	-.8386E+03	.4275E+03	.9605E+04	.5247E+04
				BEAM NO. 4			
LLoads	12	.1890E+04	.1154E+04	-.7100E+03	-.9809E+03	-.8069E+04	-.1477E+05
LLoads	3	-.1890E+04	-.1154E+04	.7100E+03	.9809E+03	.1257E+05	.2208E+05
Stress	12	-.9834E+03	.1363E+04	-.8386E+03	.4275E+03	.9605E+04	.5247E+04
Stress	3	-.9834E+03	.1363E+04	-.8386E+03	.4275E+03	.1436E+05	.8171E+04
				BEAM NO. 5			
LLoads	3	-.1869E+05	.7467E+04	.2643E+04	.8793E+04	-.1101E+05	.5449E+05
LLoads	1	.1869E+05	-.7467E+04	-.2643E+04	-.8793E+04	-.6841E-09	-.2339E+05
Stress	3	.9723E+04	.8819E+04	.3122E+04	-.3832E+04	-.3543E+05	.7161E+04
Stress	1	.9723E+04	.8819E+04	.3122E+04	-.3832E+04	-.1521E+05	-.4448E-09
				BEAM NO. 6			
LLoads	21	.2971E-12	-.2202E-10	.4149E-11	-.1787E-13	-.1138E-10	-.5805E-10
LLoads	19	-.2971E-12	.2202E-10	-.4149E-11	.1787E-13	-.1144E-10	-.5790E-10
Stress	21	-.1546E-12	-.2601E-10	.4901E-11	.7790E-14	.3775E-10	.7401E-11
Stress	19	-.1546E-12	-.2601E-10	.4901E-11	.7790E-14	-.3765E-10	-.7440E-11
				BEAM NO. 7			
LLoads	19	.1953E+04	.8053E+03	.4987E+03	.9354E+03	-.4841E+04	.4527E+04
LLoads	16	-.1953E+04	-.8053E+03	-.4987E+03	-.9354E+03	-.3064E+03	.3786E+04
Stress	19	-.1016E+04	.9512E+03	.5890E+03	-.4077E+03	-.2944E+04	.3148E+04
Stress	16	-.1016E+04	.9512E+03	.5890E+03	-.4077E+03	.2462E+04	-.1993E+03
				BEAM NO. 8			
LLoads	16	.1953E+04	.8053E+03	.4987E+03	.9354E+03	.3064E+03	-.3786E+04
LLoads	13	-.1953E+04	-.8053E+03	-.4987E+03	-.9354E+03	-.5453E+04	.1210E+05
Stress	16	-.1016E+04	.9512E+03	.5890E+03	-.4077E+03	.2462E+04	-.1993E+03
Stress	13	-.1016E+04	.9512E+03	.5890E+03	-.4077E+03	.7867E+04	-.3546E+04

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 3:F1 + F2 Cylinder Loads

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
BEAM NO. 9							
LLoads	13	.1953E+04	.8053E+03	.4987E+03	.9354E+03	.5453E+04	-.1210E+05
LLoads	11	-.1953E+04	-.8053E+03	-.4987E+03	-.9354E+03	-.8612E+04	.1720E+05
Stress	13	-.1016E+04	.9512E+03	.5890E+03	-.4077E+03	.7867E+04	-.3546E+04
Stress	11	-.1016E+04	.9512E+03	.5890E+03	-.4077E+03	.1118E+05	-.5600E+04
BEAM NO. 10							
LLoads	11	-.1843E+05	.7479E+04	-.2918E+04	-.7599E+04	.1216E+05	.4881E+05
LLoads	2	.1843E+05	-.7479E+04	.2918E+04	.7599E+04	-.2509E-09	-.1765E+05
Stress	11	.9589E+04	.8833E+04	-.3446E+04	.3312E+04	-.3174E+05	-.7904E+04
Stress	2	.9589E+04	.8833E+04	-.3446E+04	.3312E+04	-.1148E+05	-.1631E-09
BEAM NO. 11							
LLoads	3	-.6313E+04	.2058E+05	.3354E+04	-.1554E+04	-.9774E+04	.7658E+05
LLoads	4	.6313E+04	-.2058E+05	-.3354E+04	.1554E+04	.9706E+03	-.2256E+05
Stress	3	.3285E+04	.2430E+05	.3961E+04	.6771E+03	-.4979E+05	.6355E+04
Stress	4	.3285E+04	.2430E+05	.3961E+04	.6771E+03	-.1467E+05	.6311E+03
BEAM NO. 12							
LLoads	4	-.6313E+04	.2058E+05	.3354E+04	-.1554E+04	-.9706E+03	.2256E+05
LLoads	5	.6313E+04	-.2058E+05	-.3354E+04	.1554E+04	-.7832E+04	.3145E+05
Stress	4	.3285E+04	.2430E+05	.3961E+04	.6771E+03	-.1467E+05	.6311E+03
Stress	5	.3285E+04	.2430E+05	.3961E+04	.6771E+03	.2045E+05	-.5093E+04
BEAM NO. 13							
LLoads	5	-.6313E+04	.2058E+05	.3354E+04	-.1554E+04	.7832E+04	-.3145E+05
LLoads	6	.6313E+04	-.2058E+05	-.3354E+04	.1554E+04	-.1664E+05	.8546E+05
Stress	5	.3285E+04	.2430E+05	.3961E+04	.6771E+03	.2045E+05	-.5093E+04
Stress	6	.3285E+04	.2430E+05	.3961E+04	.6771E+03	.5557E+05	-.1082E+05
BEAM NO. 14							
LLoads	6	-.6313E+04	.2058E+05	.3354E+04	-.1554E+04	.1664E+05	-.8546E+05
LLoads	7	.6313E+04	-.2058E+05	-.3354E+04	.1554E+04	-.2544E+05	.1395E+06
Stress	6	.2030E+04	.1502E+05	.2448E+04	.8002E+03	.2900E+05	-.8558E+04
Stress	7	.2030E+04	.1502E+05	.2448E+04	.8002E+03	.4733E+05	-.1309E+05
BEAM NO. 15							
LLoads	7	-.6313E+04	-.2114E+05	-.3765E+04	.2956E+04	.2544E+05	-.1395E+06
LLoads	8	.6313E+04	.2114E+05	.3765E+04	-.2956E+04	-.1555E+05	.8398E+05
Stress	7	.2030E+04	-.1543E+05	-.2749E+04	-.1523E+04	.4733E+05	-.1309E+05
Stress	8	.2030E+04	-.1543E+05	-.2749E+04	-.1523E+04	.2850E+05	-.8002E+04
BEAM NO. 16							
LLoads	8	-.6313E+04	-.2114E+05	-.3765E+04	.2956E+04	.1555E+05	-.8398E+05
LLoads	9	.6313E+04	.2114E+05	.3765E+04	-.2956E+04	-.5669E+04	.2849E+05
Stress	8	.3285E+04	-.2497E+05	-.4448E+04	-.1288E+04	.5461E+05	-.1011E+05
Stress	9	.3285E+04	-.2497E+05	-.4448E+04	-.1288E+04	.1852E+05	-.3686E+04
BEAM NO. 17							
LLoads	9	-.6313E+04	-.2114E+05	-.3765E+04	.2956E+04	.5669E+04	-.2849E+05

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 3:F1 + F2 Cylinder Loads

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
LLoads	10	.6313E+04	.2114E+05	.3765E+04	-.2956E+04	.4215E+04	-.2701E+05
Stress	9	.3285E+04	-.2497E+05	-.4448E+04	-.1288E+04	.1852E+05	-.3686E+04
Stress	10	.3285E+04	-.2497E+05	-.4448E+04	-.1288E+04	-.1756E+05	.2741E+04
			***BEAM	NO. 18***			
LLoads	10	-.6313E+04	-.2114E+05	-.3765E+04	.2956E+04	-.4215E+04	.2701E+05
LLoads	11	.6313E+04	.2114E+05	.3765E+04	-.2956E+04	.1410E+05	-.8251E+05
Stress	10	.3285E+04	-.2497E+05	-.4448E+04	-.1288E+04	-.1756E+05	.2741E+04
Stress	11	.3285E+04	-.2497E+05	-.4448E+04	-.1288E+04	-.5365E+05	.9168E+04
			***BEAM	NO. 19***			
LLoads	17	-.7772E+03	-.2224E+03	-.7634E+02	-.1125E+03	.2178E+04	-.1432E+03
LLoads	18	.7772E+03	.2224E+03	.7634E+02	.1125E+03	-.1377E+04	-.2192E+04
Stress	17	.4044E+03	-.2627E+03	-.9016E+02	.4901E+02	.9315E+02	-.1416E+04
Stress	18	.4044E+03	-.2627E+03	-.9016E+02	.4901E+02	-.1425E+04	-.8953E+03
			***BEAM	NO. 20***			
LLoads	18	-.7772E+03	-.2224E+03	-.7634E+02	-.1125E+03	.1377E+04	.2192E+04
LLoads	19	.7772E+03	.2224E+03	.7634E+02	.1125E+03	-.5753E+03	-.4527E+04
Stress	18	.4044E+03	-.2627E+03	-.9016E+02	.4901E+02	-.1425E+04	-.8953E+03
Stress	19	.4044E+03	-.2627E+03	-.9016E+02	.4901E+02	-.2944E+04	-.3741E+03
			***BEAM	NO. 21***			
LLoads	17	.3778E+03	.7515E+03	.3492E+03	.3986E+03	-.3390E+04	.9192E+04
LLoads	14	-.3778E+03	-.7515E+03	-.3492E+03	-.3986E+03	-.2579E+04	.3654E+04
Stress	17	-.1966E+03	.8876E+03	.4124E+03	-.1737E+03	-.5977E+04	.2204E+04
Stress	14	-.1966E+03	.8876E+03	.4124E+03	-.1737E+03	.2376E+04	-.1677E+04
			***BEAM	NO. 22***			
LLoads	14	.3778E+03	.7515E+03	.3492E+03	.3985E+03	.2579E+04	-.3654E+04
LLoads	11	-.3778E+03	-.7515E+03	-.3492E+03	-.3985E+03	-.8547E+04	.1650E+05
Stress	14	-.1966E+03	.8876E+03	.4124E+03	-.1737E+03	.2376E+04	-.1677E+04
Stress	11	-.1966E+03	.8876E+03	.4124E+03	-.1737E+03	.1073E+05	-.5558E+04
			***BEAM	NO. 23***			
LLoads	17	.4914E+03	.2510E+04	.8654E+02	.1325E-14	-.3137E+03	.9097E+04
LLoads	22	-.4914E+03	-.2510E+04	-.8654E+02	-.1325E-14	-.4376E-11	-.3819E-10
Stress	17	-.2457E+03	.1481E+04	.5106E+02	-.1590E-13	-.6823E+04	.1881E+04
Stress	22	-.2457E+03	.1481E+04	.5106E+02	-.1590E-13	-.2864E-10	-.2623E-10
			***BEAM	NO. 24***			
LLoads	17	-.4914E+03	-.8214E+02	.7073E+02	-.1325E-14	-.2564E+03	-.2978E+03
LLoads	23	.4914E+03	.8214E+02	-.7073E+02	.1325E-14	-.2304E-12	-.2464E-10
Stress	17	.2457E+03	-.4846E+02	.4173E+02	.1590E-13	.2233E+03	.1537E+04
Stress	23	.2457E+03	-.4846E+02	.4173E+02	.1590E-13	-.1848E-10	-.1381E-11
			***BEAM	NO. 25***			
LLoads	19	.2875E+03	.1771E+04	-.6374E+02	.1141E-13	.2311E+03	.6420E+04
LLoads	24	-.2875E+03	-.1771E+04	.6374E+02	-.1141E-13	-.2634E-12	-.1679E-10
Stress	19	-.1438E+03	.1045E+04	-.3761E+02	-.1369E-12	-.4815E+04	-.1385E+04

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 3:F1 + F2 Cylinder Loads

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
Stress	24	-.1438E+03	.1045E+04	-.3761E+02	-.1369E-12	-.1259E-10	-.1579E-11
BEAM NO. 26							
LLoads	19	-.2875E+03	.4047E+03	-.3559E+02	-.1141E-13	.1290E+03	.1467E+04
LLoads	25	.2875E+03	-.4047E+03	.3559E+02	.1141E-13	.1660E-11	-.7746E-10
Stress	19	.1438E+03	.2388E+03	-.2100E+02	.1369E-12	-.1100E+04	-.7735E+03
Stress	25	.1438E+03	.2388E+03	-.2100E+02	.1369E-12	-.5809E-10	.9952E-11

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 3:F1 + F2 Cylinder Loads

MAXIMUM STRESS SUMMARY FOR BEAMS/TRUSSES
WITHIN SPECIFIED RANGE 1- 26

Maximum (absolute) Stress = .5557E+05 at BEAM 13

Beam	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
13	.3285E+04	.2430E+05	.3961E+04	.6771E+03	.5557E+05	-.1082E+05

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=============== I M A G E S 3 D ===============

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SOLVE REACTIONS Version 1.3 03/01/86

LTHD Trail Diaphragm -- 3/3/87 re-design

Load Case 3:F1 + F2 Cylinder Loads

REACTIONS

Node	Fx	Fy	Fz	Mx	My	Mz
1	-.7467E+04	.1869E+05	.2643E+04	.0000E+00	-.8793E+04	.2339E+05
2	.7479E+04	.1843E+05	.2918E+04	.0000E+00	.7599E+04	-.1765E+05
22	.8654E+02	.2510E+04	.4914E+03	.0000E+00	.0000E+00	.0000E+00
23	-.7073E+02	-.8214E+02	.4914E+03	.0000E+00	.0000E+00	.0000E+00
24	-.6374E+02	.1771E+04	.2875E+03	.0000E+00	.0000E+00	.0000E+00
25	.3559E+02	.4047E+03	.2875E+03	.0000E+00	.0000E+00	.0000E+00

PART NUMBERS: 12585792-12585797, Walking Beam Assemblies

DESCRIPTION: WALKING BEAM ASSEMBLY

The left and right hand walking beam assemblies each consist of a machined leading and lagging beam Ti6Al4V weldment. The walking beam dimensions were the result of four important considerations: maintaining clearance between the spade and the C130 ramp during loading and unloading from a C130; providing a lunette weight during emplacement and displacement light enough for two men to lift; maintaining a downward force in front of the walking beam pivot at all times (i.e, keeping the lunette on the ground) during emplacement and displacement to prevent unexpected "teetering;" and providing acceptable functional walking beam performance over large obstacles.

A complete report which summarizes the results of the supporting stress analysis can be found in the following pages of this section.

STATUS:

All design and drawing requirements have been finalized and can be found in TDP, Dwgs. 12585792-12585797.

AUTHORS: Jim Ries, Dave Boudreau

FMC Northern Ordnance Division
Minneapolis

APPLIED MECHANICS

Subject	Analyst	
LTHD – LEAD/LAG BEAM ASSY	J. RIES	
	Project Number	
	EC. No.	Date 12/30/86

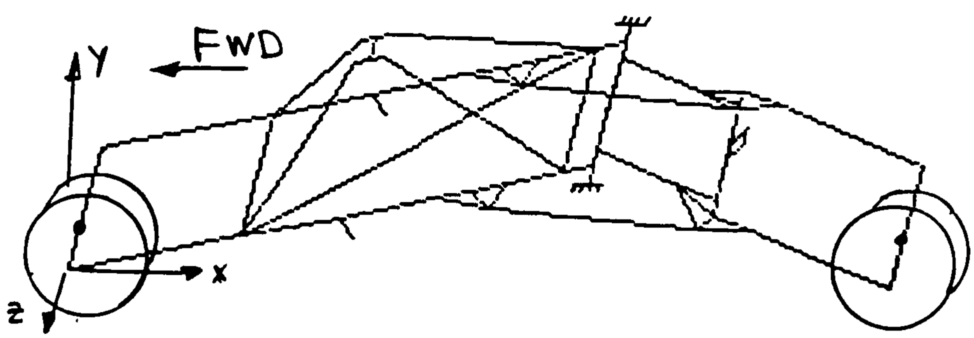
A. INTRODUCTION

A FINITE ELEMENT ANALYSIS OF THE LEADING/LAGGING BEAM ASSEMBLY (FORMERLY IDENTIFIED AS THE WALKING BEAM ASSEMBLY) WAS PERFORMED TO DETERMINE DEFLECTIONS AND STRESSES DUE TO STATIC LOADINGS. THE ASSEMBLY IS A WELDED FRAME TYPE STRUCTURE PRIMARILY MADE OF TITANIUM WITH SEVERAL STEEL COMPONENTS (AXLES, PIVOT TUBE & CYLINDER ATTACHMENT PINS). A PC PROGRAM, IMAGES3D VERSION 1.3, WAS USED FOR THE ANALYSIS.

B. FINITE ELEMENT MODEL

1. GEOMETRY, NODE & ELEMENT NUMBERS

THE FOLLOWING SKETCHES IDENTIFY GEOMETRY LAYOUT, NODE NUMBERS, ELEMENT NUMBERS AND DIMENSIONS.



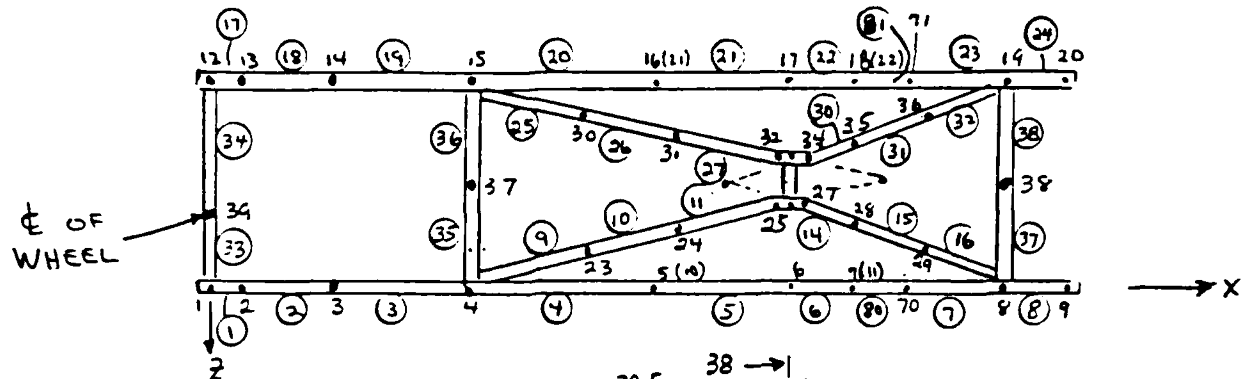
FINITE ELEMENT MODEL SCHEMATIC

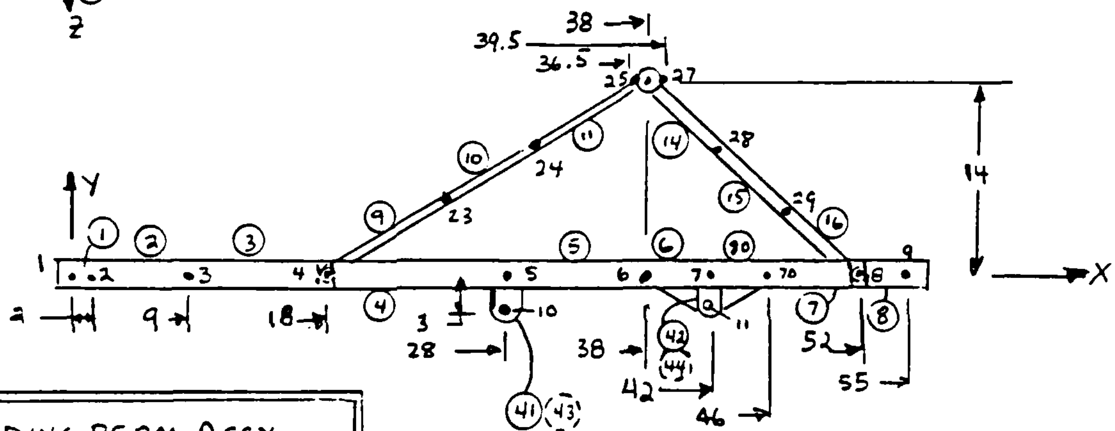
DA-6490ct85

FMC Northern Ordnance Division
Minneapolis

APPLIED MECHANICS

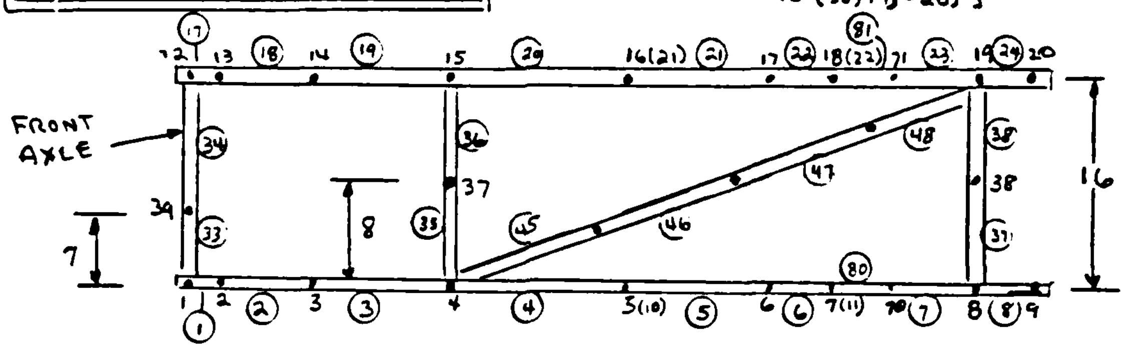
Subject	Analyst	
LTHD – LEAD/LAG BEAM ASSY.	J. RIES	
	Project Number	
	EC. No	Date 6/30/86

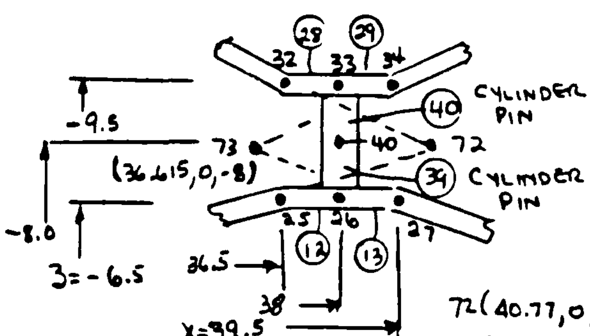




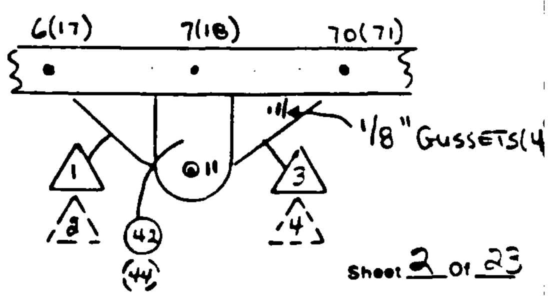
LEADING BEAM ASSY.
(PRIOR TO INSTALLATION

• 75 (38, 0, -30)
• 76 (38, 14, -20) } DUMMY NODES





72 (40.77, 0, -8)
73 (36.615, 0, -8) } DUMMY NODES



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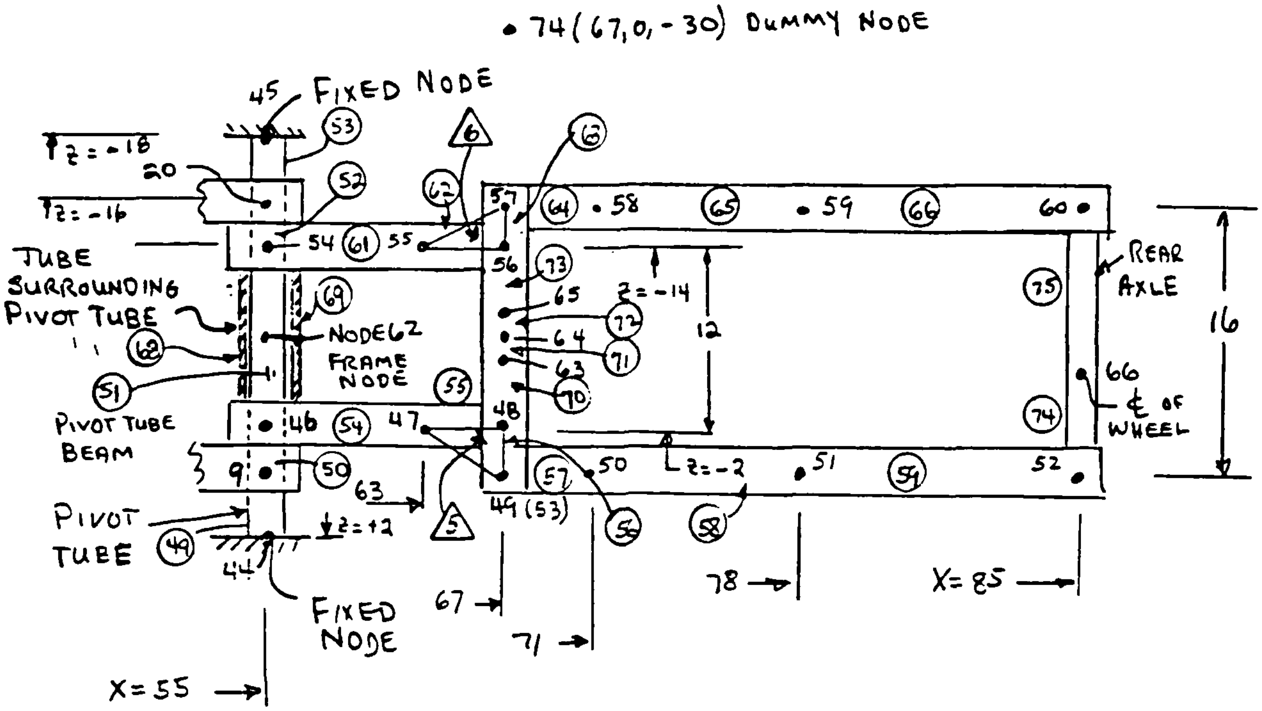
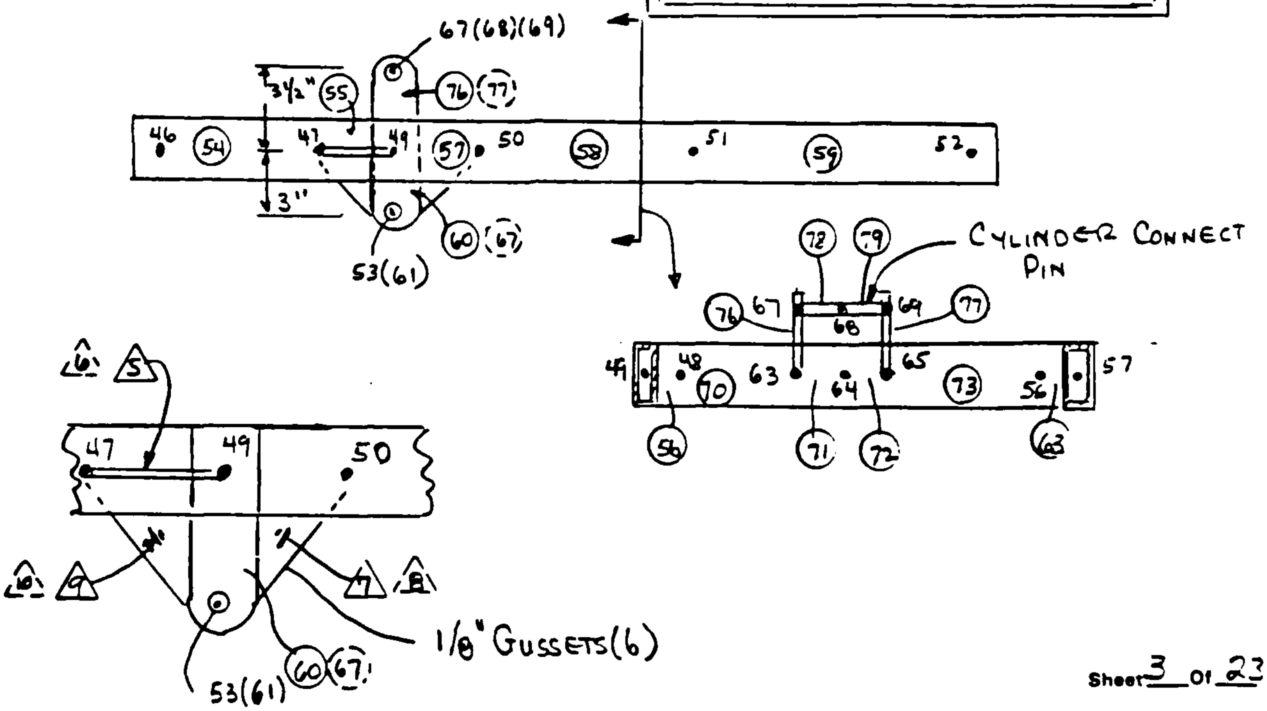
Minneapolis

APPLIED MECHANICS

Subject	Analyst	
LTHD - LEAD/LAG BEAM ASSY.	J. RIES	
	Project Number	
	EC. No.	Date 12/30/86



LAGGING BEAM ASSY. PRIOR TO INSTALLATION



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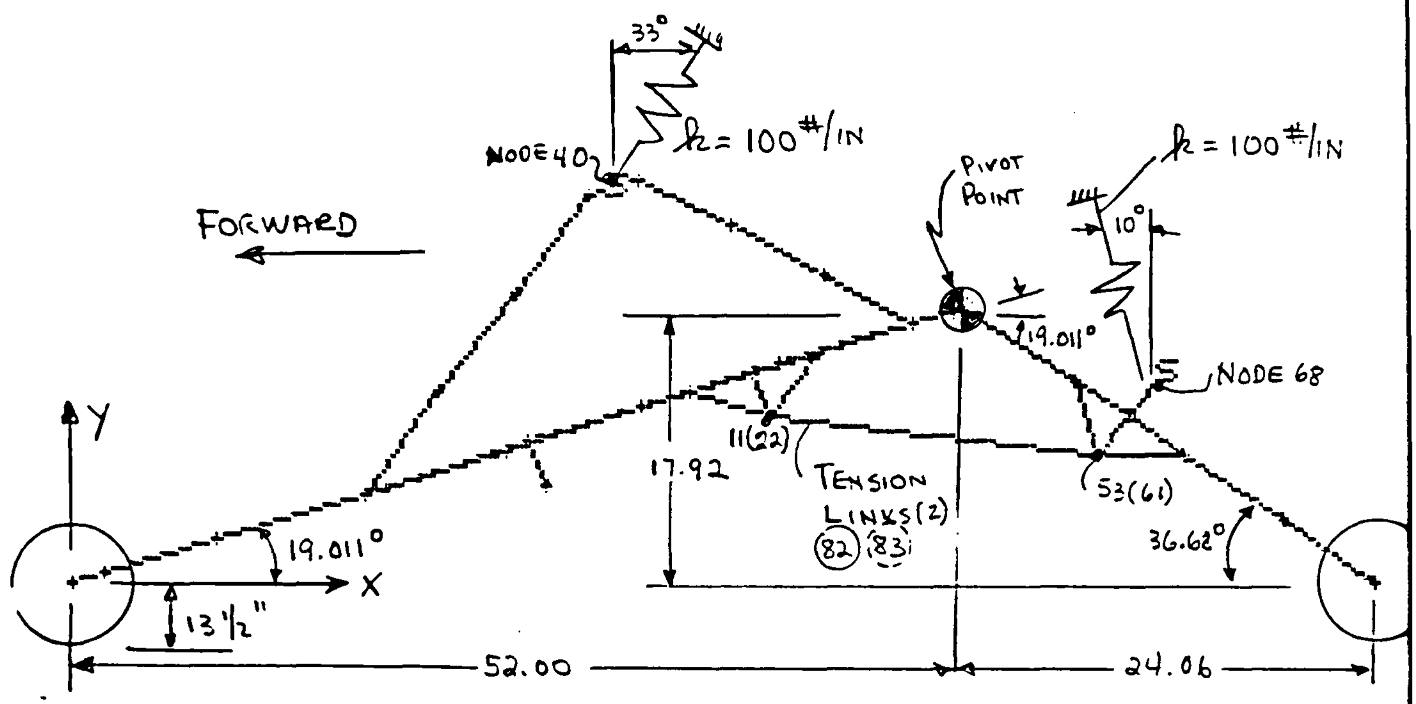
Minneapolis

APPLIED MECHANICS

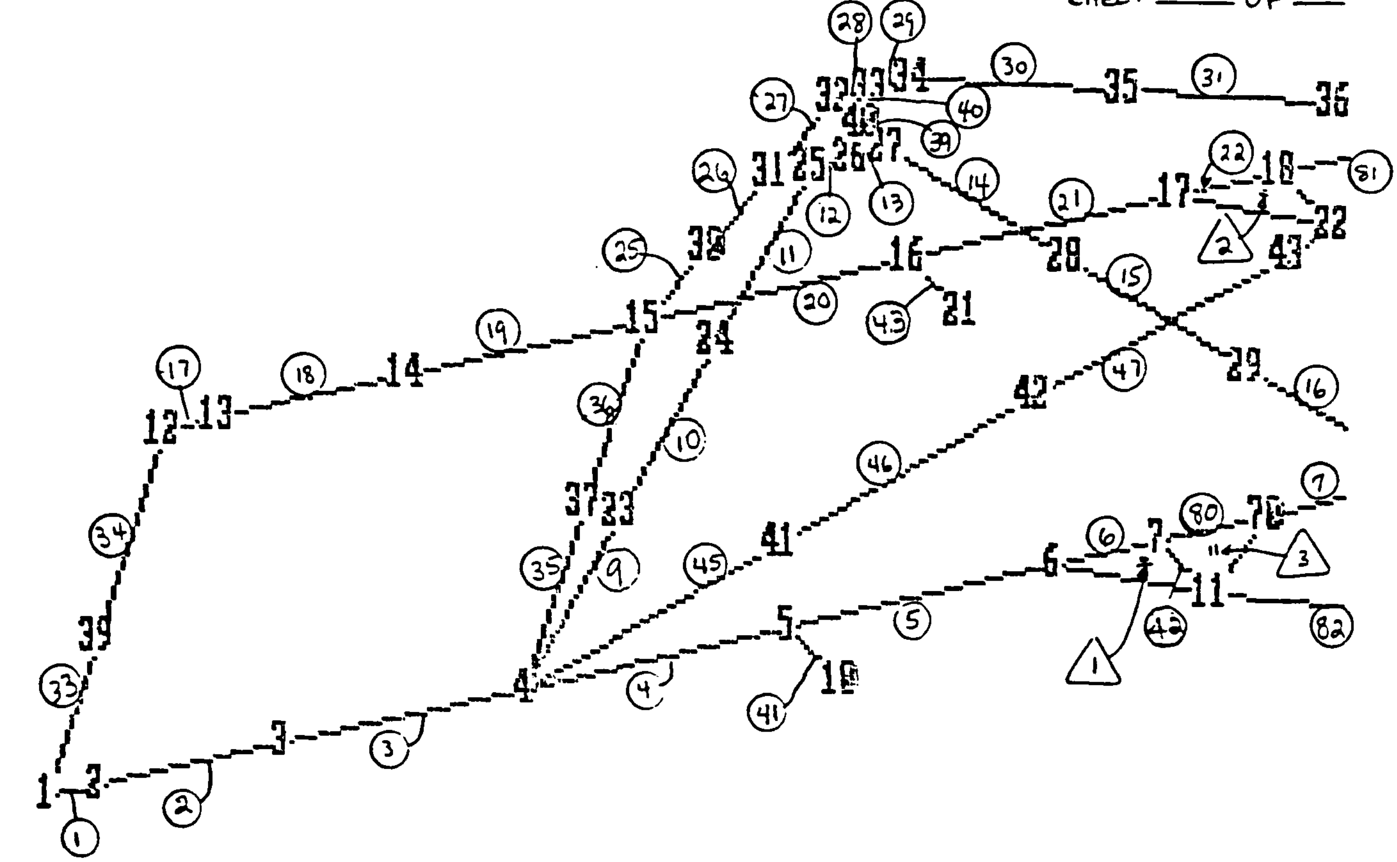
Subject	Analyst	
LTHD - LEAD/LAG BEAM ASSY.	J. RIES	
	Project Number	
	EC. No.	Date 12/30/86



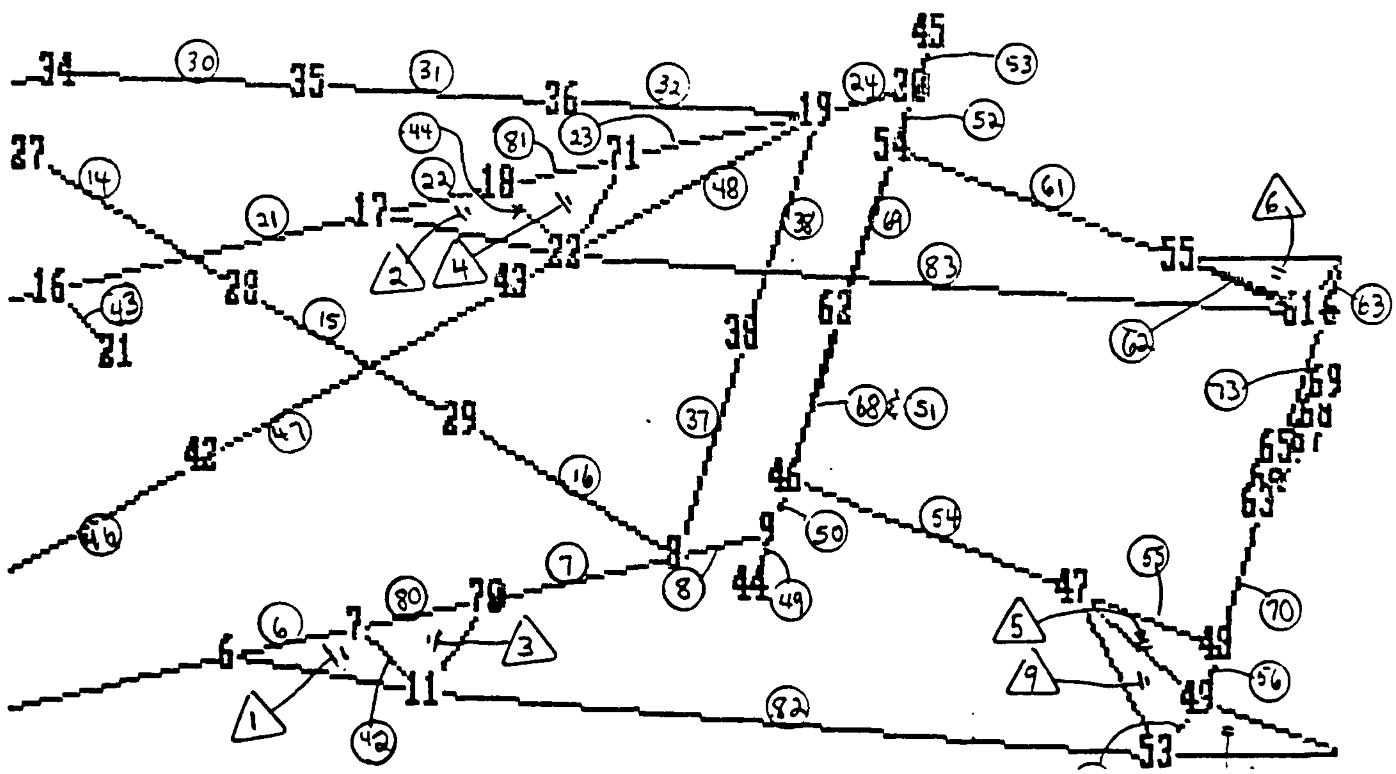
NOTES: (1) WEAK SPRINGS TO GROUND ARE CONNECTED TO THE CYLINDER CONNECT PINS (NODES 40 & 68) ALLIGNED ALONG THE DIRECTIONS OF THE HYDRAULIC CYLINDERS. THESE ARE USED PRIMARILY TO PREVENT RIGID BODY MODES IN THE FINITE ELEMENT MODEL. THE LOADS IN THE SPRINGS SHOULD BE RELATIVELY SMALL SINCE THE CYLINDERS ARE NOT PRESSURIZED IN THE LOAD CASES BEING INVESTIGATED,

(2) THE NODE COORDINATES AND ELEMENT CONNECTIVITY WILL BE ENTERED IN IMAGES3D USING THE "PRIOR TO INSTALLATION" CONFIGURATION & COORDINATE SYSTEM FOR CONVENIENCE PURPOSES. ALL THE NODES WILL BE ROTATED 19.011° FROM THE ORIGINAL COORDINATE SYSTEM. THEN, ALL NODES IN THE LAGGING BEAM ASSY. WILL BE ROTATED IN THE REVERSE DIRECTION 55.691° (19.011° + 36.68°). THIS WILL RESULT IN THE CONFIGURATION SHOWN ABOVE WHICH WILL BE USED IN THE ANALYSIS.

(3) THE FOLLOWING 2 PAGES SHOW NODE & ELEMENT NUMBERING



NODE & ELEMENT NUMBERING



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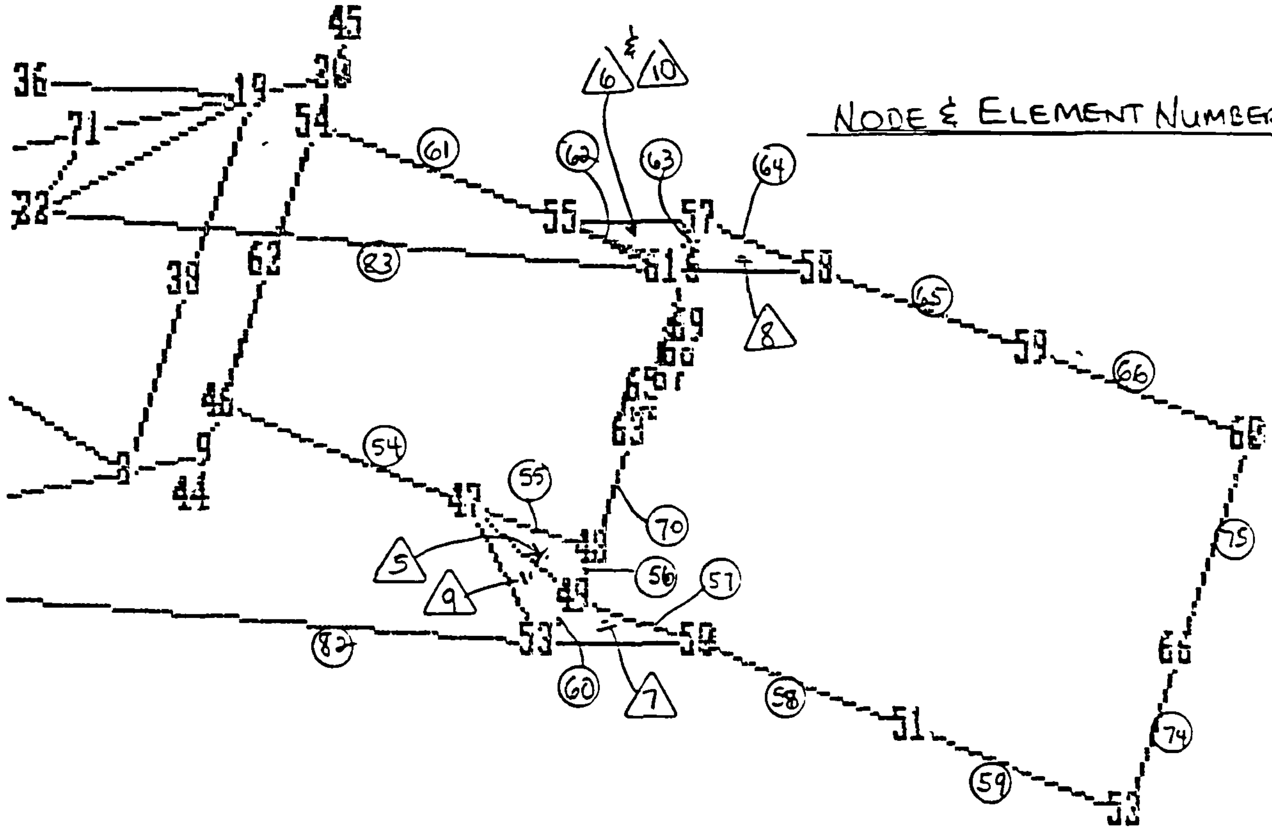
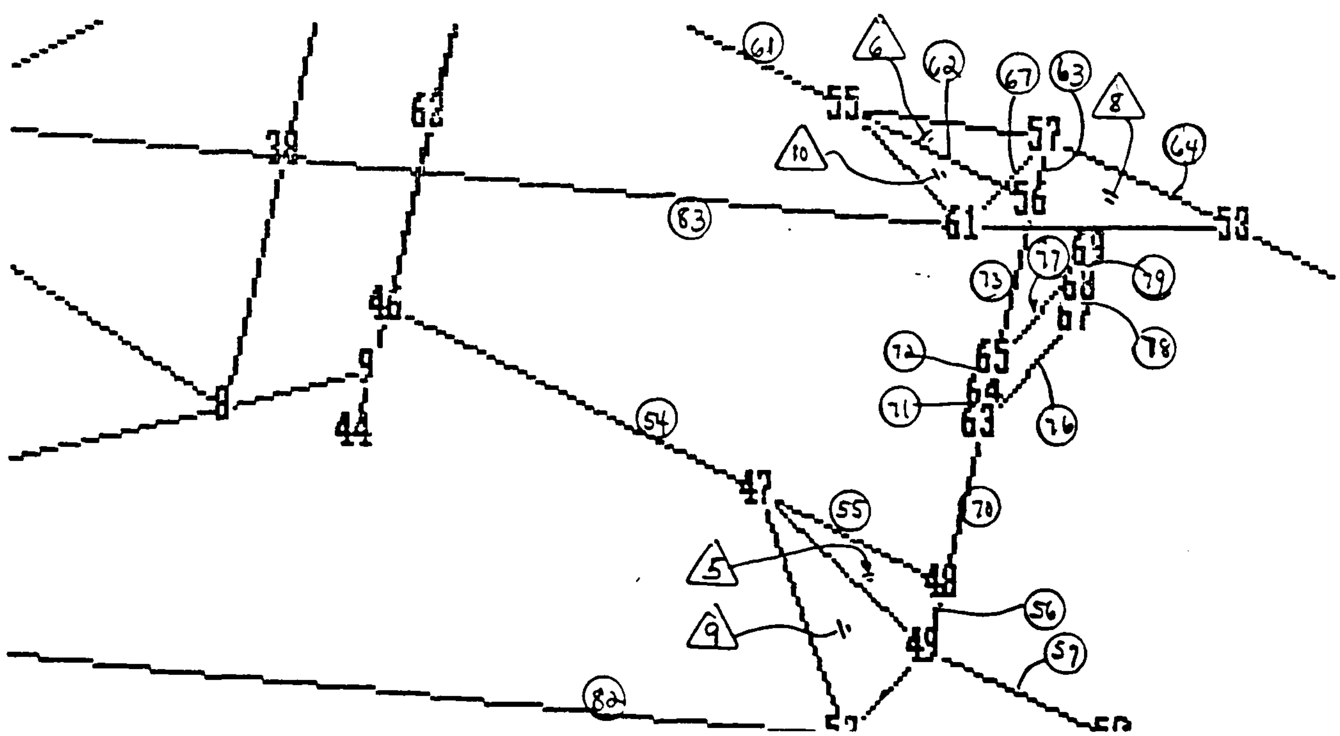
SHEET 6 OF 23

NODE & ELEMENT NUMBERING





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APPLIED MECHANICS

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LTHD - LEAD/LAG BEAM ASSY	J. RIES	
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2. MATERIAL PROPERTIES

MATERIAL 1 - TITANIUM, Ti 6Al 4V

ALL FRAME MEMBERS ARE MADE FROM TITANIUM HAVING PROPERTIES:

F_{tu} = 130,000 psi $G = 6.2 \times 10^6$ psi

F_{ty} = 120,000 psi ν = 0.31

$E = 16.0 \times 10^6$ psi ρ = 0.16 #/IN³

MATERIAL 2 - STEEL

THE AXLES, PIVOT TUBE & CYLINER CONNECT PINS ARE MADE FROM STEEL (AISI 4340 HT) HAVING PROPERTIES:

F_{tu} = 150,000 psi $G = 11.5 \times 10^6$ psi

F_{ty} = 132,000 psi ν = .3

$E = 30 \times 10^6$ psi ρ = .22 #/IN³

THE BEAMS HAVING THESE PROPERTIES ARE: 33, 34, 39, 40, 49, 50, 51, 52, 53, 74, 75, 78 & 79

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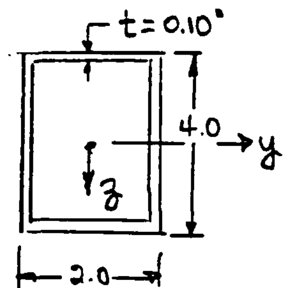
3. BEAM CROSS-SECTION PROPERTIES

PROPERTY 1 – MAIN FRAME (BOTTOM) BEAMS, TITANIUM



$A = 4\times2 - 3.8\times1.8 = 1.16\ \mathrm{IN}^2$

$I_y = \frac{1}{12}(4)^3(2) - \frac{1}{12}(3.8)^3(1.8) = 2.436\ \mathrm{IN}^4$

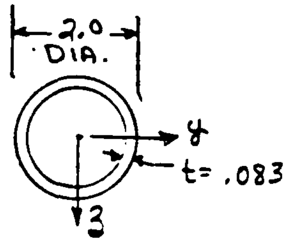
$I_z = \frac{1}{12}(2)^3(4) - \frac{1}{12}(1.8)^3(3.8) = 0.8199\ \mathrm{IN}^4$

ASSUME t IS SMALL, THEN: $J \approx \dfrac{2t^2(a^2)(b^2)}{t(a)+t(b)-2t^2} \approx \dfrac{2(.1)^2(4)^2(2)^2}{.1(4)+.1(2)-2(.1)^2} \approx 2.207\ \mathrm{IN}^4$

C_τ = FACTOR FOR CALCULATING TORSION SHEAR STRESS $= \dfrac{(a-t)(b-t)}{a+b-2t} = 1.179$ "

$SSF_y = SSF_z$ = SHEAR SHAPE FACTOR = 2.27 (FOR SHEAR DEFORMATIONS)

PROPERTY 2 – FRAME SUPPORT BEAMS, TITANIUM



$A = \frac{\pi}{4}(2^2 - 1.834^2) = 0.500\ \mathrm{IN}^2$

$I_y = I_z = \frac{\pi}{4}(1^4 - .917^4) = 0.230\ \mathrm{IN}^4$

$J = 2I_y = 0.460\ \mathrm{IN}^4$

C_τ = radius = 1.0 IN

$SSF_y = SSF_z = 1.89$

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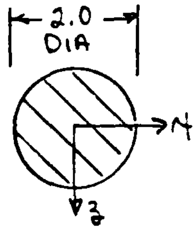
PROPERTY 3 - STEEL AXLE, BEAM NO'S. 33, 34, 74 & 75



$A = \pi r^2 = \pi(1)^2 = 3.1416 \text{ IN}^2$

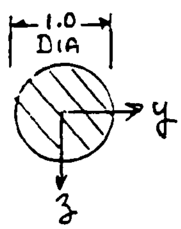
$I_y = I_z = \frac{\pi}{4} r^4 = \frac{\pi}{4}(1)^4 = .7854 \text{ IN}^4$

$J = 2 I_y = 1.5708 \text{ IN}^4$

C_r = Radius = 1.0 IN

$SSF_y = SSF_z = 1.12$

PROPERTY 4 - STEEL CYLINDER CONNECT PIN, BEAM NO'S. 39, 40, 78 & 79



$A = \pi r^2 = \pi(.5)^2 = .7854 \text{ IN}^2$

$I_y = I_z = \frac{\pi}{4} r^4 = \frac{\pi}{4}(.5)^4 = .04909 \text{ IN}^4$

$J = 2 I_y = .09817 \text{ IN}^4$

C_r = RADIUS = 0.5 IN

$SSF_y = SSF_z = 1.12$

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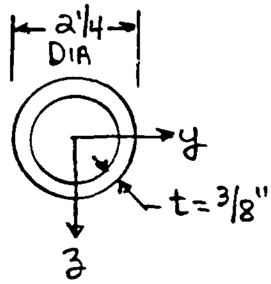
PROPERTY 5 - STEEL PIVOT TUBE, BEAM NO'S. 49, 50, 51, 52 & 53



$$A = \pi(1.125^2 - .75^2) = 2.209 \text{ IN}^2$$

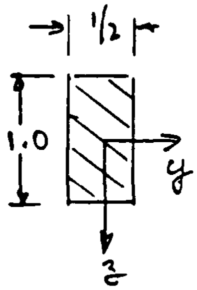
$$I_y = I_z = \frac{\pi}{4}(1.125^4 - .75^4) = 1.010 \text{ IN}^4$$

$$J = 2I_y = 2.019 \text{ IN}^4$$

$$C_\tau = \text{Radius} = 1.125 \text{ IN}$$

$$SSF_y = SSF_z = 1.89$$

PROPERTY 6 - TENSION LINK & ATTACHMENT LUGS, TITANIUM
BEAM NO'S. 82, 83, 41, 42, 43, 44, 60, 67, 76 & 77



$$A = 1 \times 1/2 = 0.5 \text{ IN}^2$$

$$I_y = \frac{1}{12}(1)^3(\tfrac{1}{2}) = .04167 \text{ IN}^4$$

$$I_z = \frac{1}{12}(1/2)^3(1) = .01042 \text{ IN}^4$$

$$J \approx 0.22bt^3 = 0.22(1)(\tfrac{1}{2})^3 = .0286 \text{ IN}^4$$

$$C_\tau \approx \frac{\beta}{\alpha} t = \frac{.229}{.246} \times .5 = .4654 \text{ IN}$$

$$SSF_y = SSF_z = 1.25$$

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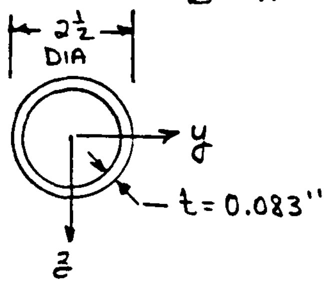
PROPERTY 7 - FRAME TUBE SURROUNDING PIVOT TUBE, TITANIUM
BEAM NO'S. 68 & 69



$A = \pi(1.25^2 - 1.167^2) = .6302 \text{ IN}^2$

$I_y = I_z = \frac{\pi}{4}(1.25^4 - 1.167^4) = .4608 \text{ IN}^4$

$J = 2 I_y = .9215 \text{ IN}^4$

C_τ = RADIUS = 1.25 IN

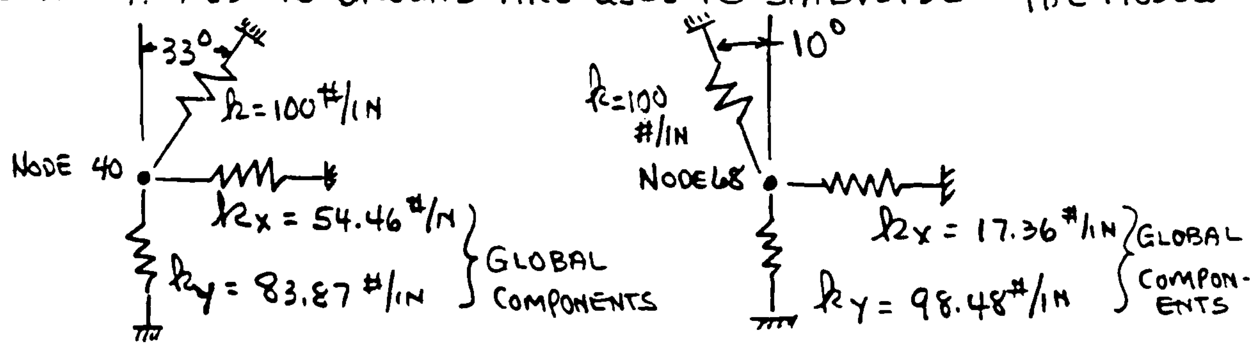
$SSF_y = SSF_z = 1.89$

4. RESTRAINTS

THE 2 PIVOT TUBE END NODES, NUMBERS 44 & 45, ATTACH TO THE LTHD TRAIL. THESE NODES WILL BE ASSUMED FIXED IN ALL 6 DIRECTIONS FOR THIS ANALYSIS.

5. SPRINGS TO GROUND

WEAK SPRINGS TO GROUND ARE USED TO STABILISE THE MODEL



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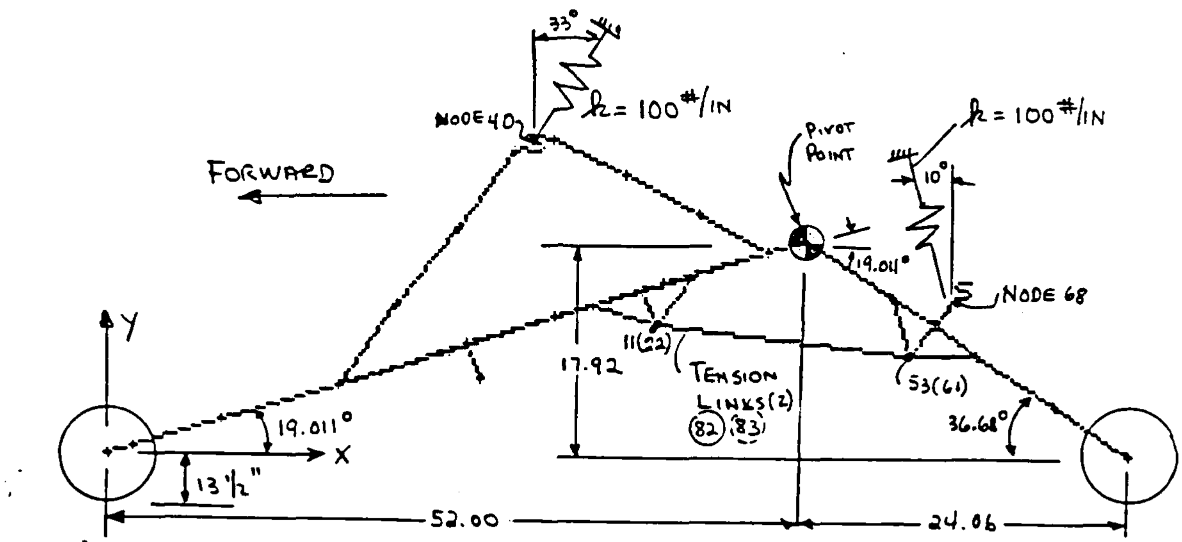
C. STATIC LOAD CASES

THREE STATIC LOAD CASES, REPRESENTING 2 TOWING CONDITIONS AND 1 TRANSPORTATION AIRCRAFT LANDING LOAD CONDITION, WILL BE CONSIDERED. THE LOADINGS WILL BE APPLIED TO THE FOLLOWING CONFIGURATION



1. LOAD CASE 1 – SKID PLUS BUMP ON FRONT TIRE / TOWING

a. SKID LOAD

(1) ASSUME THE LTHD IS NEARLY TIPPING OVER SO THAT ALL 9000# OF DEAD WEIGHT IS SUPPORTED BY ONE LEADING/LAGGING BEAM ASSY.

(2) ASSUME COEFFICIENT OF FRICTION BETWEEN TIRE & ROAD SURFACE IS 0.8

(3) ASSUME SKID FORCE IS APPLIED EQUALLY TO EACH TIRE

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THE SKID FORCE ON EACH TIRE IS THEREFORE :

$$F_z = -\frac{9000^{\#}}{2} \times 0.8 = -3600^{\#}$$ APPLIED AT CONTACT SURFACE

b. BUMP LOAD

ASSUME THE BUMP LOAD IS 1/2 OF TOTAL LTHD WEIGHT

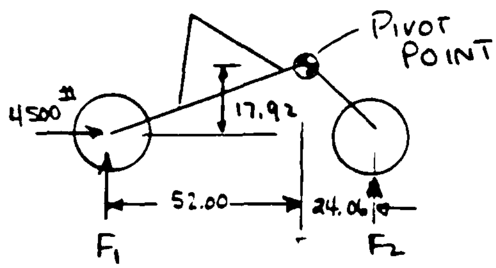
$$F_x = +\,9000^{\#}/2 = +4500^{\#}$$ APPLIED AT THE AXLE NODE

C. VERTICAL LOAD

ASSUME THE VERTICAL LOAD COMPONENT APPLIED AT THE TIRES IS THE TOTAL DEAD WEIGHT MINUS THE WEIGHT SUPPORTED BY THE LUNETTE

$$F_y = 9000^{\#} - 1200^{\#} = 7800^{\#}$$

THE DISTRIBUTION OF THE VERTICAL LOAD MUST BE IN EQUILIBRIUM ABOUT THE PIVOT POINT



$$F_1 + F_2 = 7800^{\#}$$

$$4500 \times 17.92 + 24.06 F_2 = 52 F_1$$

$$F_1 = 3527.4^{\#}$$
$$F_2 = 4272.6^{\#}$$

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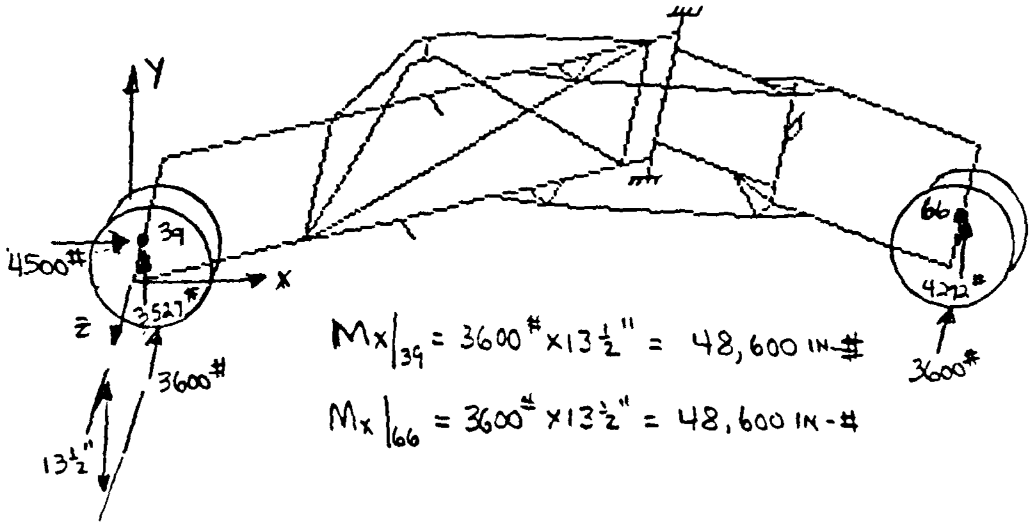
THE RESULTING LOAD DIAGRAM FOR LOAD CASE 1 BECOMES

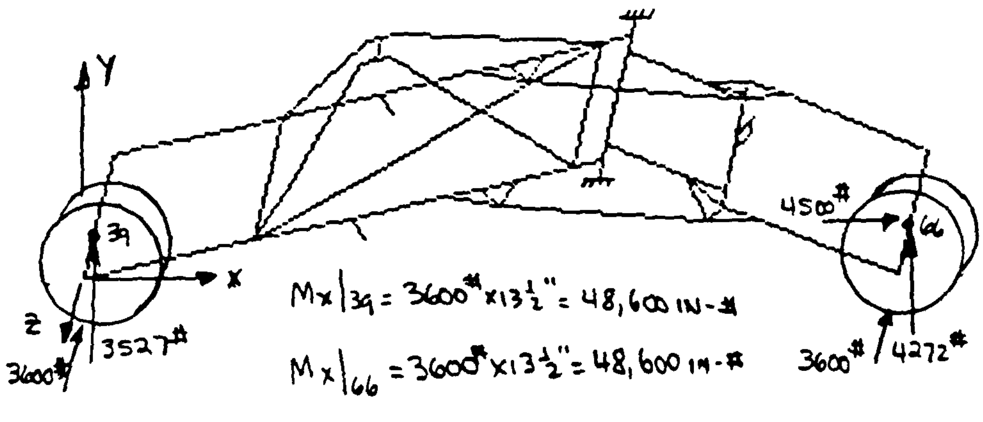


$M_x|_{39} = 3600^{\#} \times 13\tfrac{1}{2}'' = 48{,}600$ IN-#

$M_x|_{66} = 3600^{\#} \times 13\tfrac{1}{2}'' = 48{,}600$ IN-#

2. LOAD CASE 2 – SKID PLUS BUMP ON REAR TIRE, TOWING

THE LOAD DIAGRAM FOR LOAD CASE 2 IS



$M_x|_{39} = 3600^{\#} \times 13\tfrac{1}{2}'' = 48{,}600$ IN-#

$M_x|_{66} = 3600^{\#} \times 13\tfrac{1}{2}'' = 48{,}600$ IN-#

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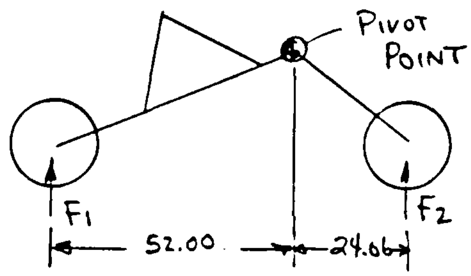
3. LOAD CASE 3 - AIRCRAFT TRANSPORTATION 4 1/2 G LANDING LOAD

IN THE TRANSPORTATION CONDITION EACH OF THE 2 BEAM ASSEMBLIES TAKE 1/2 OF THE DEAD WEIGHT MINUS THE WEIGHT SUPPORTED BY THE LUNETTE



$$F_1 + F_2 = 4\tfrac{1}{2}G \times \left(9000^{\#} - 1200^{\#}\right) \times \tfrac{1}{2} = 17{,}550^{\#}$$

LUNETTE SUPPORTED WEIGHT

$$52 F_1 = 24.06 F_2$$

$F_1 = 5551.6^{\#}$ $\qquad$ $F_2 = 11{,}998.4^{\#}$

D. EXECUTING IMAGES 3D

THE NODE COORDINATES, ELEMENT CONNECTIVITY, MATERIAL AND BEAM CROSS-SECTION PROPERTIES, RESTRAINTS, SPRINGS TO GROUND AND STATIC LOADS WERE ENTERED INTO THE IMAGES3 FINITE ELEMENT PROGRAM. THE ATTACHED OUTPUT LISTING GIVES THE RESULTS OF THE ANALYSIS COVERING PROCESSED GEOMETRY DATA, NODAL DISPLACEMENTS & ELEMENT FORCES & STRESSES

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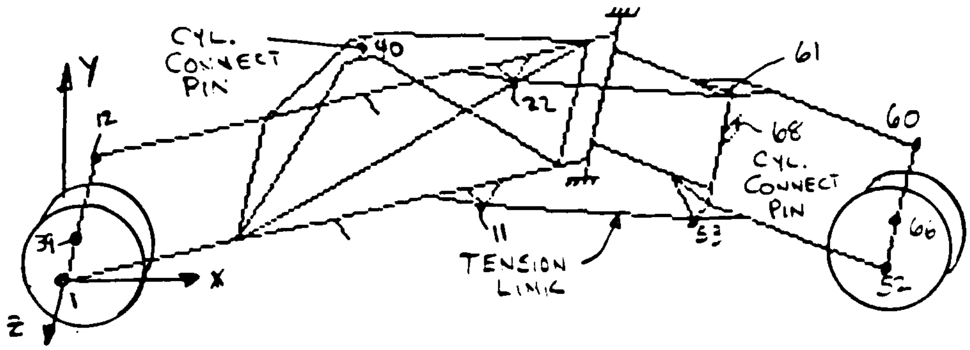
E. ANALYSIS RESULTS SUMMARY

FOLLOWING IS A SUMMARY OF THE CRITICAL STRESS & DISPLACEMENT RESULTS. COMPLETE STRESS & DISPLACEMENT RESULTS ARE GIVEN IN THE ATTACHED OUTPUT LISTING

1. SUMMARY OF DISPLACEMENT RESULTS

THE CRITICAL DISPLACEMENTS ARE SUMMARIZED BELOW:



NODE NUMBERS SHOWN

NODE NO.	DISPLACEMENTS								
	LOAD CASE 1			LOAD CASE 2			LOAD CASE 3		
	X	Y	Z	X	Y	Z	X	Y	Z
1	-.045	.070	-.365	-.132	.326	-.370	-.340	1.022	.019
39	-.103	.345	-.365	-.205	.598	-.370	-.334	1.017	-.019
12	-.203	.666	-.365	-.292	.913	-.370	-.324	.970	.019
11	.026	-.052	-.066	.053	-.100	-.068	.087	-.124	-.002
53	.042	.006	-.102	.092	.047	-.105	.169	.170	-.004
22	.032	-.028	-.066	.056	-.067	-.067	.082	-.119	.010
61	.071	.106	-.093	.116	.144	-.089	.156	.151	.021
52	.120	.128	-.297	.288	.358	-.296	.592	.864	.012
66	.189	.288	-.297	.364	.511	-.297	.573	.868	.012
60	.280	.453	-.297	.434	.663	-.296	.544	.788	.012
40	.033	.054	.042	.055	.082	.042	.099	.148	.005
68	.023	.086	-.059	.041	.151	-.060	.065	.247	-.001

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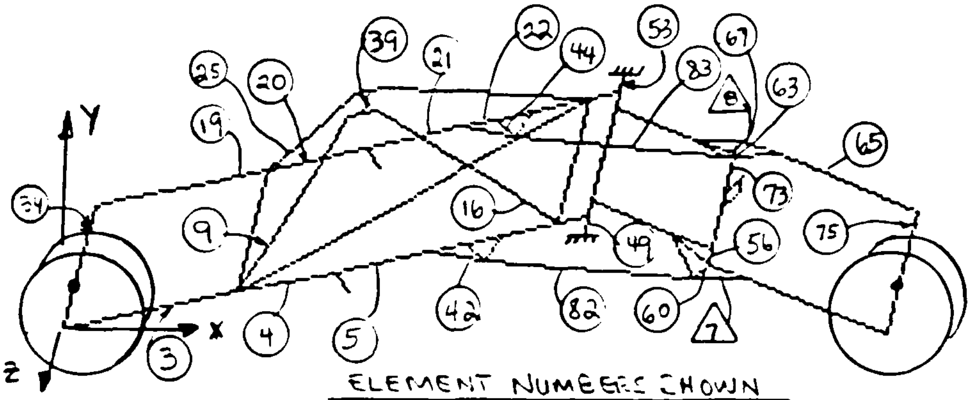
2. SUMMARY OF STRESS RESULTS, LOAD CASE 1

MAXIMUM STRESSES FOR CRITICAL MEMBERS ARE SUMMARIZED IN THE FOLLOWING TABLE



ELEMENT NUMBERS SHOWN

ELEMENT NO.	STRESSES, PSI				COMMENT
	σ_{axial}	$\tau_{torsion}$	$\sigma_{y\text{-}bend}$	$\sigma_{z\text{-}bend}$	
3/19	+4748	−6897	±20,010	±28,310	SECTION
4	+9279	−3248	± 49	± 11,490	SECTION
5/21	−4496	−3368	± 2170	±35,870	SECTION
9/25	−4964	+2681	± 33,150	± 5326	SECTION
16	− 4028	−2101	±24,620	± 6294	SECTION
20	−4496	−3368	± 797	± 24,360	SECTION
22	−4045	−3365	± 2167	±35,870	SECTION

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ELEMENT No.	STRESSES σ_{axial}	$\tau_{torsion}$	σ_y-bend	σ_z-bend	COMMENTS
34	−624	0	± 34,700	± 32,390	SECTION – FWD. AXLE
39	−269	0	± 16,810	± 65,310	SECT. – CYL. CONNECT PIN
60/67	+6196	−97	± 6681	± 29,530	SECT. – TENSION LINK LUG
42/44	+49.3	+134	± 4	± 23,450	SECT. – TENSION LINK LUG
49/53	+1579	0	± 10,930	± 27,060	SECT. – PIVOT TUBE
56/63	+3140	−12,910	± 29,350	± 4343	SECTION
73	+620	−3866	± 32,380	± 779	SECTION
65	−4604	+4583	± 4478	± 30,200	SECTION
75	−573	0	± 33,800	± 41,630	SECT. – AFT AXLE
82	+6364	0	0	0	SECT. – TENSION LINK
84	+17,860	0	0	0	SECT. – TENSION LINK
△7/△8		$\tau_{xy} = -29,000$	$\sigma_x = -2816$	$\sigma_y = +6241$	1/8" GUSSET STIFFENER

THE MINIMUM FACTORS OF SAFETY FOR THIS LOAD CASE ARE

STEEL AXLE: $F.S. = F_{ty}/(\sigma_a \pm \sqrt{\sigma_y^2+\sigma_z^2}) = 132{,}000/(-573 \pm \sqrt{33200^2+41630^2}) = 2.44$

STEEL PIVOT: $F.S. = F_{ty}/(\sigma_a \pm \sqrt{\sigma_y^2+\sigma_z^2}) = 132000/(1579 \pm \sqrt{10930^2+27060^2}) = 4.29$

STEEL CYL. PIN: $F.S. = F_{ty}/(\sigma_a \pm \sqrt{\sigma_y^2+\sigma_z^2}) = 132000/(-269 \pm \sqrt{16810^2+65310^2}) = 1.95$

FRAME BOX: $F.S. = F_{ty}/(\frac{1}{2}\sigma \pm \sqrt{(\frac{1}{2}\sigma)^2+\tau^2}) = 120000/(26534 \pm \sqrt{26{,}534^2+6897^2}) = 2.52$

WHERE $\sigma = \sigma_a \pm \sigma_y \pm \sigma_z = 4748 \pm 20{,}010 \pm 28310 = 53068$

FRAME TUBE: $F.S. = F_{ty}/(\frac{1}{2}\sigma \pm \sqrt{(\frac{1}{2}\sigma)^2+\tau^2} = 120000/(19270 \pm \sqrt{19270^2+2658^2}) = 3.18$

WHERE $\sigma = \sigma_a \pm \sqrt{\sigma_y^2 \pm \sigma_z^2} = -4964 \pm \sqrt{33{,}150^2+5326^2} = -38540$

LUG: $F.S. = F_{ty}/(\sigma_a \pm \sigma_y \pm \sigma_z) = 120000/(6196 \pm 6681 \pm 29530) = 2.83$

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TENSION LINK: $F.S. = F_{ty}/\sigma_a = 120000/17860 = 6.72$

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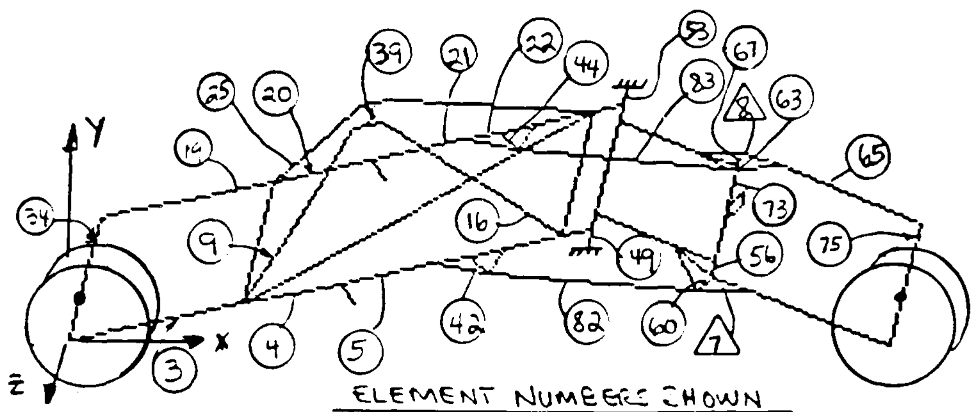
3. SUMMARY OF STRESS RESULTS, LOAD CASE 2

MAXIMUM STRESSES FOR CRITICAL MEMBERS ARE SUMMARIZED IN THE FOLLOWING TABLE



ELEMENT NUMBERS SHOWN

ELEMENT NO.	STRESSES				COMMENT
	σ_{axial}	$\tau_{torsion}$	$\sigma_{y\text{-}bend}$	$\sigma_{z\text{-}bend}$	
3/19	-3149	-6461	± 18,400	± 32,440	◻ SECTION
4	+11,570	-3257	± 83	± 25360	◻ SECTION
5/21	-2724	-3336	± 2183	± 54,930	◻ SECTION
9/25	-5279	+3170	± 45,410	± 1746	◎ SECTION
16	-4372	-1703	± 39,060	± 116	◎ SECTION
20	-2724	-3336	± 5279	± 37,850	◻ SECTION
22	-2631	-3333	± 2180	± 54,930	◻ SECTION

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ELEMENT No.	STRESSES σ_{axial}	$\tau_{torsion}$	σ_y-bend	σ_z-bend	COMMENTS
34	-595	0	±18,230	±45,210	SECTION - FWD. AXLE
39	-376	0	±19,630	±62,640	SECT. - CYL. CONNECT PIN
60/67	+8434	-57	±9308	±44,870	SECT. - TENSION LINK LUG
42/44	+6824	+132	±4	±35,310	SECT. - TENSION LINK LUG
49/53	-1573	0	±8106	±29140	SECT. - PIVOT TUBE
56/63	+3186	-18,640	±30,090	±1599	SECTION
73	+507	-3612	±39,210	±2229	SECTION
65	-3248	+3766	±3479	±45360	SECTION
75	-476	0	±20,130	±54190	SECT. - AFT AXLE
82	+16,370	0	0	0	SECT. - TENSION LINK
84	+26,860	0	0	0	SECT. - TENSION LINK
A/B		$\tau_{xy}=-43,280$	$\sigma_x=-647$	$\sigma_y=+9517$	1/8" GUSSET STIFFENER

THE MINIMUM FACTORS OF SAFETY FOR THIS LOAD CASE ARE;

STEEL AXLE: $F.S. = F_{ty}/(\sigma_a \pm \sqrt{\sigma_y^2+\sigma_z^2}) = 132000/(-476 \pm \sqrt{20130^2+54190^2}) = 2.26$

STEEL PIVOT: $F.S. = F_{ty}/(\sigma_a \pm \sqrt{\sigma_y^2+\sigma_z^2}) = 132000/(-1573 \pm \sqrt{8102^2+29140^2}) = 4.15$

STEEL CYL. PIN: $F.S. = F_{ty}/(\sigma_a \pm \sqrt{\sigma_y^2+\sigma_z^2}) = 132000/(-376 \pm \sqrt{19630^2+62640^2}) = 2.00$

FRAME BOX: $F.S. = F_{ty}/(\tfrac{1}{2}\sigma \pm \sqrt{(\tfrac{1}{2}\sigma)^2+\tau^2} = 120000/(29871 \pm \sqrt{29871^2+3333^2}) = 2.00$

WHERE $\sigma = \sigma_a \pm \sigma_y + \sigma_z = -2631 \pm 2180 \pm 54930 = -59741$

FRAME TUBE: $F.S. = F_{ty}/(\tfrac{1}{2}\sigma \pm \sqrt{(\tfrac{1}{2}\sigma)^2+\tau^2} = 120000/(25361 \pm \sqrt{25361^2+3170^2} = 2.36$

WHERE $\sigma = \sigma_a \pm \sqrt{\sigma_y^2+\sigma_z^2} = -5279 \pm \sqrt{45410^2+1746} = -50,723$

LUG: $F.S. = F_{ty}/(\sigma_a \pm \sigma_y \pm \sigma_z) = 120000/(8434 \pm 9308 \pm 44,870) = 1.92$

Sheet 20 of 23

TENSION LINK: $F.S. = F_{ty}/\sigma_a = 120000/26,860 = 4.47$

DA-6490c:85

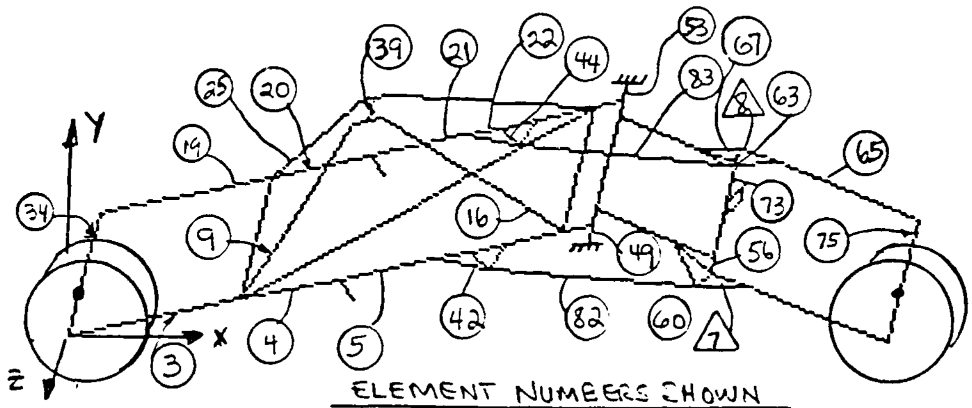
FMC Northern Ordnance Division
Minneapolis

APPLIED MECHANICS

Subject	Analyst
LTHD – LEAD/LAG BEAM ASSY.	J. RIES
	Project Number
	EC. No. / Date 1/5/87

4. SUMMARY OF STRESS RESULTS, LOAD CASE 3

MAXIMUM STRESSES FOR CRITICAL MEMEERS ARE SUMMARIZED IN THE FOLLOWING TABLE



ELEMENT NUMEERS SHOWN

ELEMENT NO.	STRESSES				COMMENT
	σ_{axial}	$\tau_{torsion}$	σ_{y-bend}	σ_{z-bend}	
3/19	-893	-116	±759	± 41,050	▯ SECTION
4	+162	+293	± 231	± 49,220	▯ SECTION
5/21	+162	+293	± 637	± 73,000	▯ SECTION
9/25	-1823	-1001	± 55,790	± 13,160	◎ SECTION
16	-1519	+1547	± 52,880	± 23,050	◎ SECTION
20	+146	+265	± 717	± 48,390	▯ SECTION
22	-239	+265	± 130	± 68,160	▯ SECTION

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Minneapolis

APPLIED MECHANICS

Subject	Analyst	J. RIES
LTHD – LEAD/LAG BEAM ASSY.	Project Number	
	EC. No.	Date 1/5/87

ELEMENT No.	STRESSES σ_{axial}	$\tau_{torsion}$	σ_y-bend	σ_z-bend	COMMENTS
34	−16	0	±7318	±24,480	SECTION – FWD. AXLE
39	−414	0	±13,590	±7892	SECT. – CYL. CONNECT PIN
60/67	+11,000	−129	±10,480	±60,640	SECT. – TENSION LINK LUG
42/44	+8560	−11	±1	±46,800	SECT. – TENSION LINK LUG
49/53	+292	0	±14,110	±36,910	SECT. – PIVOT TUBE
56/63	+2307	+23,270	±14,350	±6047	SECTION
73	+1534	+947	±9952	±6893	SECTION
65	−2677	−2936	±7414	±52,150	SECTION
75	+53	0	±30,780	±45,000	SECT. – AFT AXLE
82	+35,760	0	0	0	SECT. – TENSION LINK
84	+32,270	0	0	0	SECT. – TENSION LINK
7/8		τ_{xy} = −57,010	σ_x = +1004	σ_y = ±12,800	1/8" GUSSET STIFFENER

THE MINIMUM FACTORS OF SAFETY FOR THIS LOAD CASE ARE

STEEL AXLE: $F.S. = F_{ty}/(\sigma_a \pm \sqrt{\sigma_y^2+\sigma_z^2}) = 132000/(+53 \pm \sqrt{30780^2+45000^2}) = 2.42$

STEEL PIVOT: $F.S. = F_{ty}/(\sigma_a \pm \sqrt{\sigma_y^2+\sigma_z^2}) = 132000/(+292 \pm \sqrt{14110^2+36910^2}) = 3.32$

STEEL CYL. PIN: $F.S. = F_{ty}/(\sigma_a \pm \sqrt{\sigma_y^2+\sigma_z^2}) = 132000/(-414 \pm \sqrt{13590^2+7892^2}) = 8.18$

FRAME BOX: $F.S. = F_{ty}/(\frac{1}{2}\sigma \pm \sqrt{(\frac{1}{2}\sigma)^2+\tau^2}) \quad 120000/(36900^2 \pm \sqrt{36900^2+293^2} = 1.63$

WHERE $\sigma = \sigma_a \pm \sigma_y \pm \sigma_z = 162 \pm 637 \pm 73000 = +73,800$

FRAME TUBE: $F.S. = F_{ty}/(\frac{1}{2}\sigma \pm \sqrt{(\frac{1}{2}\sigma)^2+\tau^2}) = 120000/(29600^2 \pm \sqrt{29600^2+1547^2} = 2.02$

WHERE $\sigma = \sigma_a \pm \sqrt{\sigma_y^2+\sigma_z^2} = -1519 \pm \sqrt{52880^2+23050^2} = 59200$

LUG: $F.S. = F_{ty}/(\sigma_a \pm \sigma_y \pm \sigma_z) = 120000/(11,000 \pm 10480 \pm 60640) = 1.46$

TENSION LINK: $F.S. = F_{ty}/\sigma_a = 120000/35760 = 3.36$

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Minneapolis

APPLIED MECHANICS

Subject	Analyst	
LTHD - LEAD/LAG BEAM ASSY.	J. RIES	
	Project Number	
	EC. No.	Date 1/7/87

F. CONCLUSION

THE MINIMUM FACTOR OF SAFETY FOUND FOR THE 3 STATIC LOAD CASES INVESTIGATED WAS 1.46. THIS OCCURED IN ONE OF THE TENSION LINK LUGS (BEAM ELEMENT NO. 60) FOR THE AIRCRAFT TRANSPORTATION 4 1/2 G LANDING LOAD (LOAD CASE 3). THIS IS SLIGHTLY LOWER THE THE DESIGN FACTOR OF SAFETY GOAL OF 1.50 FOR METAL COMPONENTS BASED ON MATERIAL YIELD STRENGTH. HOWEVER, IN THE ANALYSIS THIS LUG WAS ASSUMED TO BE A BAR WITH A CROSS SECTION OF 1" x 1/2". AS A RESULT OF THIS ANALYSIS THE LUG'S CROSS SECTION SIZE WILL BE INCREASED TO 2"x1" WHICH WILL SIGNIFICANTLY INCREASE THE FACTOR OF SAFETY BEYOND 1.50. SINCE ALL OTHER FACTORS OF SAFETY ARE GREATER THAN 1.50, THIS DESIGN IS ACCEPTABLE FOR THE THREE STATIC LOAD CASES INVESTIGATED.

LTNS - WIT

11-16-86
WRR.
REV. A

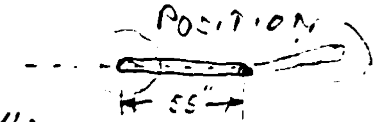
1.

OPTIMUM WHEEL LOCATION

$$\begin{array}{r} 283.625 \\ 95.77 \\ \hline 187.855 \end{array} \qquad \begin{array}{r} 9113 \\ 650 = W_2 \\ \hline 8463 = W_1 \end{array}$$

$F_1 \approx 50$

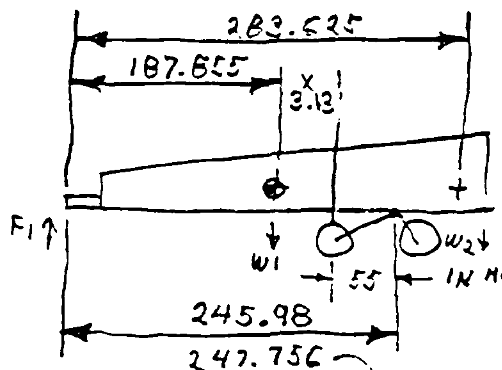
ASSUMES HORIZ POSITION



$$F_1 \cdot 187.85 + F_1 \cdot X - \overset{W_1}{8463} + \overset{W_2}{650} \cdot .55 = 0$$

$$X\left(F_1 - W_1\right) = -W_2 \cdot .55 - F_1 \cdot 187.85$$

$$X = \frac{(650 \cdot .55) + (50 \cdot 187.85)}{8463 - 50} = 3.13$$



CURRENT LOCATION ON CAD-ASSY.
1.78 DIFFERENCE

$$3.13 + 55 = 58.13$$

$$58.13 + 187.85 = 245.98$$

$$F_1 \cdot 245.98 - W_1 \cdot 58.13 = 0$$

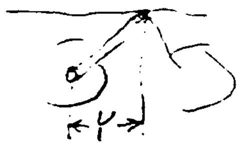
$$F_1 = \frac{8463 \cdot 58.13}{245.98} = 1{,}999.9 \text{ POUNDS}$$

LTHD-WIT OPTIMUM WHEEL LOCATION 11-16-86 ARQ 2.

WHEELS IN TOW POSITION

$$(F_1 \cdot 187.85) + (F_1 \cdot X) - (8463 \cdot X) + (650 \cdot Y) = 0$$

$Y = 51.25$



WHEELS IN TOW POS.

WHEELS HORIZ. $X_1 = 5.36$

$F_1 = $ (SOLVE FOR TOW POS.) WHEELS IN TOW $X_1 \approx 9.11$

$$(F_1 \cdot 187.85) + (F_1 + 6.88) - (8463 \cdot 6.88 + 650 \cdot 51.25) = 0$$

$$(F_1 \cdot 187.85) + (F_1 + 6.88) = (8463 \cdot 6.88) - (650 \cdot 51.25)$$

$$F_1 = \frac{(8463 \cdot 6.88) - (650 \cdot 51.25)}{187.85 + 6.88}$$

$F_1 = 127.9$ POUNDS

$F_1 = $ (SOLVE FOR LIFTING LUNETTE OFF TRUCK) $Y = 47.67$
BASED ON REAR WHEEL 3" OFF THE GROUND $X \approx 10.46$

$$F_1 = \frac{(8463 \cdot 10.46) - (650 \cdot 47.67)}{187.85 + 10.46}$$

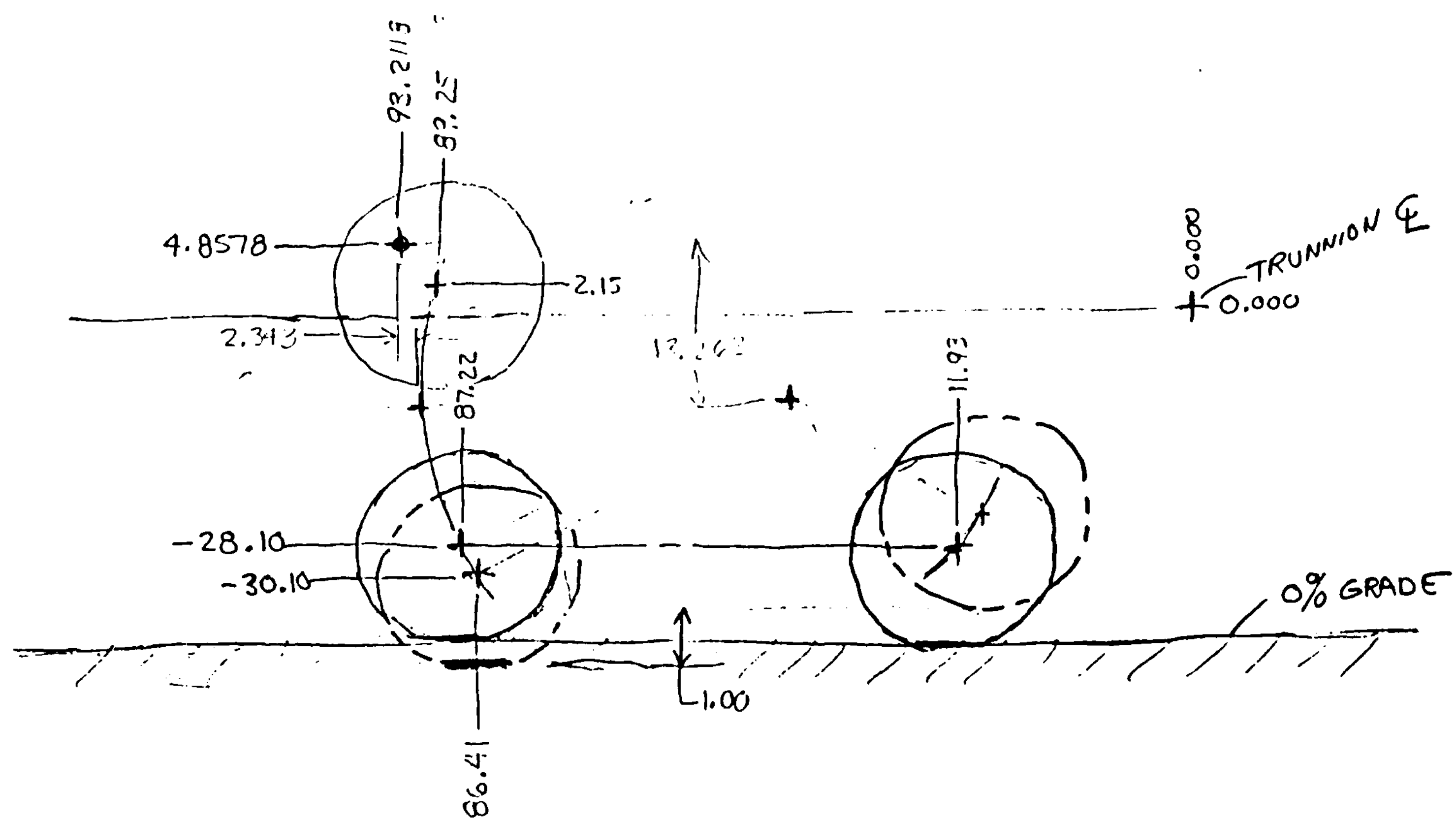
$F_1 = 290.1$ POUNDS

LTTU
TOTAL WEIGHT = 8463
C.G. X COORD (IN) = -.948718E-01
C.G. Y COORD (IN) = 4.86224
C.G. Z COORD (IN) = 95.7703
JYZ (FT-LB-S^2) = 26434.5
JXY (FT-LB-S^2) = 490.222
JXZ (FT-LB-S^2) = 26517.3

DESCRIPTION	WEIGHT	X	Y	Z
3200 BARREL	2650	0	0	101.9
3225 TWD	15	0	0	8.2
3300 BREECH	495	-.5	0	8.2
3340 MB NUT	3	0	0	243
3362 BAND	90	0	0	14.5
3364 BRCH ACT	12	0	10.5	14.5
3368 BRCH V	4	12	0	14.5
3380 Y&W	310	0	0	134.7
3400 AUTOPR	30	-.6	-.8	0
3450 M BRAKE	158	0	-1.8	261.7
6755R CMPACT	100	0	12.5	79
3720 CRADLE	430	-.33	.96	127.1
4275 SPSHASSY	50	0	-15.5	139
4284 BAND	15	0	-10	14
4286 FRTMNFDK	12	0	0	241
4288 MMNFLDK	13	0	0	127
5225 CABLE	19	0	25.4	61.4
5250 C PLLEYS	16	0	25.4	61.4
5302 CP PINS	4	0	33.5	6.9
5304 SPELCYL	8	0	33.8	2.8
3090 PAINT	20	0	0	96
5830 HBSYSTRL	8	0	16	246
6330 HBSYSTRL	8	0	16	246
6580 CAN1MNFD	32	20	0	24
6590J PIPCR	27	15.5	13	120
6590K HO SET	6	15.5	13	0
6670 BRKAIRL	5	0	16	246
6755NR COMP	535	0	12.5	184
6950 EQUNIT	342	0	8.5	177
7150 ELEV CYL	64	0	16.7	5.4
7260 EQ ACC	85	-5	10.75	184
7270 ERA	186	0	0	184
7272 NITROGEN	30	0	0	184
7290 F ACC	90	0	22.75	184
7292 NITROGEN	5	0	22.75	184
7300 HYDFL	200	0	12.5	184
4200 TR BRG	30	0	0	0
4320 FLTUBE	44	0	0	-22
4322 S FRAMES	20	0	10	47
4410 PLTFM W	450	0	12.4	-23
4420 UTRAVSH	7	0	40.5	-16.5
4525 SPADE	201	0	-20	-20
4700 LTRAVSH	12	0	-9	-16.5
4950 LIFT EYE	14	0	47	-23.5
5000 GIMBAL	331	0	16	-16.5
5610 LH TRAIL	300	41.75	7.7	113.4
5620 OPEN	0	0	0	0
5840 LH CLAW	55	41.75	-18	250.9
5960 LH TR P	8	41.75	5	239.1
6110 RH TRAIL	300	-41.75	7.7	113.4
6120 OPEN	0	0	0	0
6340 RH CLAW	55	-41.75	-18	250.9

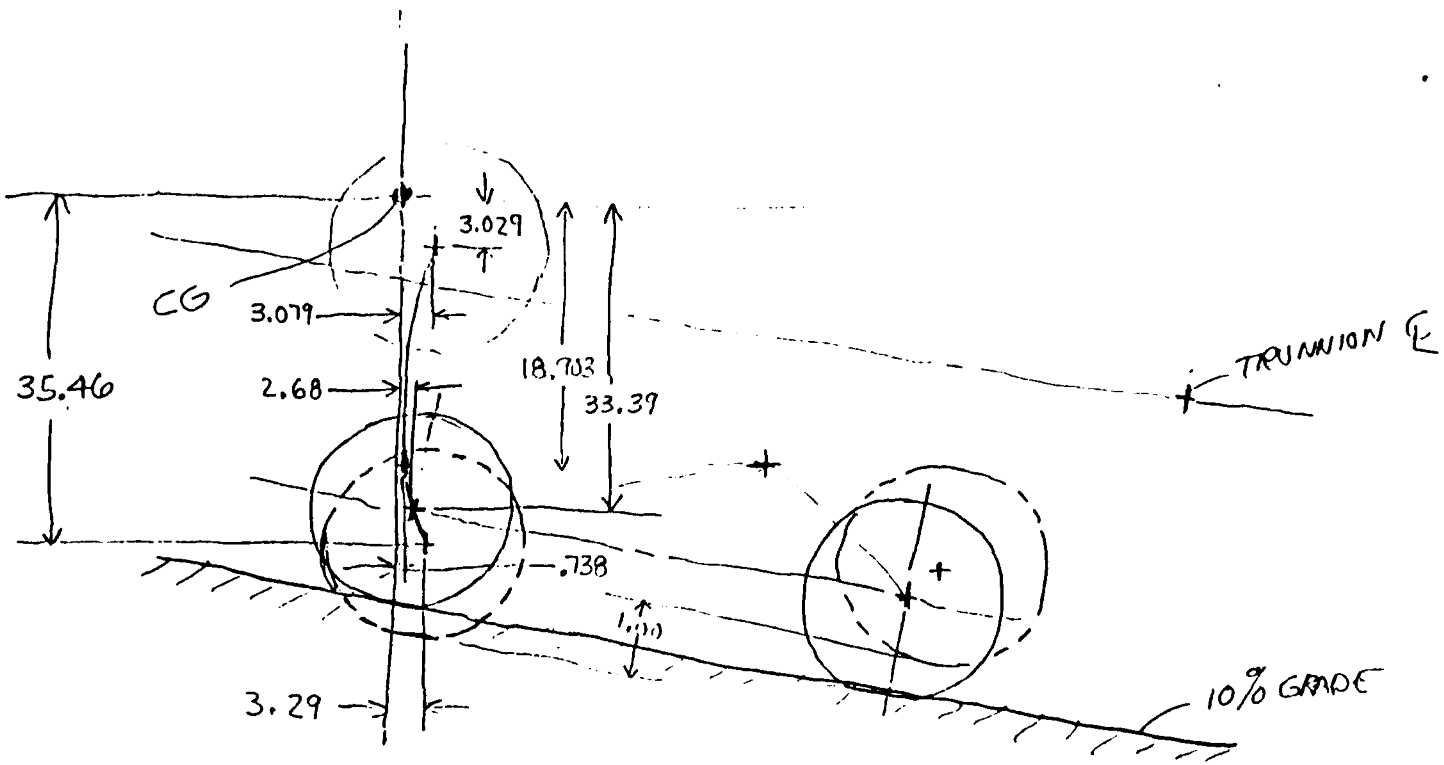
6360	RH TR P	8	-41.75	5	239.1
6560	G CNTRL	32	17	28	-35
6570	AG CNTRL	32	-17	28	-35
6600	TRAV CYL	65	-18	-4.5	-15
6660	TAIL LI	5	0	36	-26
7950	AG FC	44	0	24	45
8150	G FC	100	0	24	45
4280	BII BC	33	0	24	45
8350	BIIS	240	0	24	45

86-11 5



Need [illegible] 2 points
C.G. can never be behind front wheel

29


3.029
CG
3.079
2.68
35.46
18.703
33.39
TRUNNION ℄
.738
3.29
10% GRADE

PART NUMBERS: 12585741, Wheel Hubs
12585747, Wheel Axles
12585739, Wheels
12585738, Tires

DESCRIPTION: WHEEL HUBS, AXLES, WHEELS, TIRES

Hubs and Axles -

For the wheel hubs, a Finite Element Analysis was performed to evaluate stresses under air transport and towing ("bump and slip") loads with 6061-T6 Aluminum alloy used for the material. Results indicate a minimum factor of safety of 3.13 under worst-case conditions. For a complete report of the wheel hub stress analysis, including a description of the approach used, FEA models, and results, see the following pages of this section.

The axle analysis was performed in conjunction with the walking beam analysis above and these results can also be found in the following pages of this section.

Wheels and Tires -

The 25.0 lb. wheels are made by American Racing Equipment and are heat treated cast aluminum. All four wheels are identical. All four tires are Goodyear Tracker LT-2 8.75-16.5LT tires and weigh 36.0 lb. each.

STATUS:

All specifications for the wheel hubs (TDP, Dwg. 12585741) and axles (TDP, Dwg. 12585747) have been determined and are supported by a complete stress analysis.

Complete specifications for the wheels and tires have been finalized and can be found in the TDP, Dwgs. 12585739 and 12585738 respectively.

AUTHORS: Joe Fishbein, Jim Ries, Dave Boudreau

LTHD Project

Wheel Hub Stress Analysis Report

by Joe Fishbein
27 Feb 1986

I. Introduction

The purpose of this analysis is to determine the suitability of 6061-T6 Aluminum alloy (σy = 35,000 PSI) for the LTHD wheel hub. The hub is a machined hollow tube with flanges for the wheel and brake disk. Roller bearings mounted on the ends of the hub attach the wheel/hub assembly to the axle, which passes through the center of the hub.

Wheel loadings were taken from the analysis of the Walking Beam assembly. These loads are caused by transport of the LTHD under two conditions:

1) Bump and Skid during transport. This condition generates horizontal and vertical loads in the plane of the wheel, as well as an eccentric load normal to the wheel.

2) Air Drop. This condition generates a vertical load in the wheel plane from the 4.5G impact.

Finite Element Analysis was performed to evaluate stresses under these loadings. A minimum factor of safety of 2.0 against yielding was used as a failure criteria.

II. Finite Element Models

For this analysis, two models were analyzed on the IMAGES-3D program. These models are described below:

1) Simple Beam model. This model, shown in Figure 1, was used to evaluate general stresses in the hub. It consists of a series of hollow circular beam elements. Section properties were determined from the inside and outside diameters of the hub at each element location. Beam ends are restrained at the bearing centerlines, and loads are applied to the front edge of the wheel flange.

2) Plate Model. This model, shown in Figure 2, was used to obtain more localized stresses in the hub. A series of membrane/bending plate elements are located on the center of the cross-section, with plate thicknesses determined by the actual hub wall thickness at each element location. An additional plate at the

wheel flange bolt circle is added to offset the loads to the front flange surface. These plates are rotated around the hub axis to generate a 1/2-shell model. The end bearings are modeled by "rigid" springs to the hub axis, with axial displacement fixed at the brake end bearing. Loads are applied to discrete points at 45° intervals around the flange, simulating the eight wheel bolts.

By using a half model, sufficient detail can be incorporated into the model without exceeding the limits of the IMAGES program. For the bump and skid loading condition, the resultant of the horizontal and vertical in-plane loads was applied vertically. While this is not the exact loading, it is conservative in that the maximum stresses from the in-plane and perpendicular loads occur at the same point, rather than being circumferentially offset. This also permits a single run with symmetric boundary conditions, rather than two runs with symmetric/anti-symmetric boundaries and an algebraic combination.

III. Analysis Results

The highest stresses occur under bump and skid loading, mainly from the eccentric moment. However, stresses in general are low. For the simple beam model, the maximum stress, a combination of axial compression and bending, is -4,963 PSI. This occurs in the barrel of the hub just behind the wheel flange. The plate model revealed some additional local bending in this region, with a maximum stress of -11,190 PSI. The Factor of Safety for this stress is 3.13. The actual stress in this area will be lower, due to a generous fillet between the flange and barrel which was not included in the model, and the loading assumption mentioned above.

Maximum deflection is .0078 in. at the top edge of the wheel flange, and -.0060 in. at the bottom edge. This results in an angular displacement of the wheel of 0.098°.

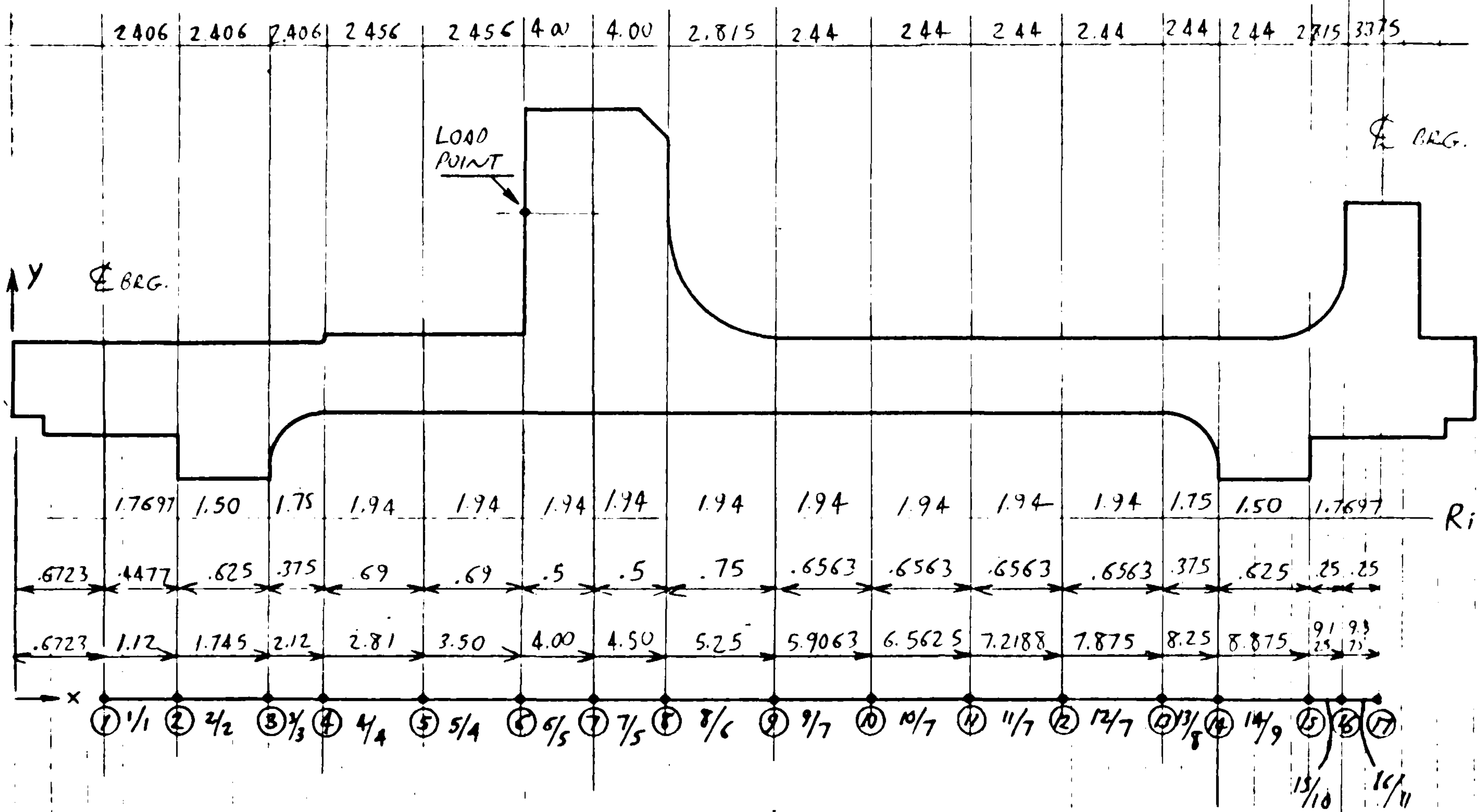
Stresses in the second load case (4.5G air drop) are significantly lower. Maximum stress in the beam model is 3,223 PSI, occurring in the barrel ahead of the wheel flange. The corresponding stress in the plate model is 3,879 PSI.

Details of the models and stress results are attached to this report.

fn=lthdhub.doc

LTP HUB
2/25/87

SIMPLE BEAM MODEL



⑥ NODE ID

8/6 ELEMENT ID/ PROPERTY NO.

FIGURE 1

Subject	Analyst	
LTHD	[illegible]	
	Project Number	
	EC. No.	Date 2-25-87

BEAM SECTION PROPERTIES

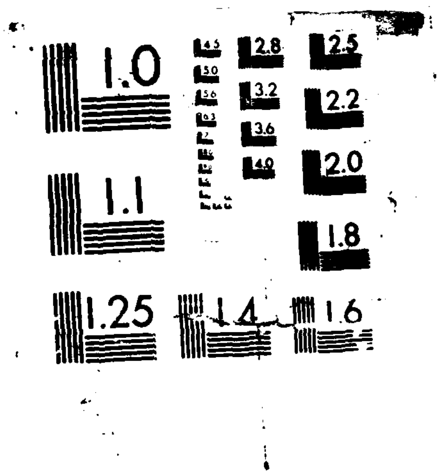
PID	R_o	R_i	A	I	J
1	2.406	1.7697	8.3472	18.6157	37.2313
2	2.406	1.500	11.1176	22.3431	44.6862
3	2.406	1.750	8.5650	18.9530	37.9060
4	2.456	1.940	7.1262	17.4512	34.9024
5	4.000	1.940	38.4418	189.9370	379.8740
6	2.815	1.940	13.0710	38.1929	76.3857
7	2.440	1.940	6.8801	16.7138	33.4276
8	2.440	1.750	9.0827	20.4725	40.9451
9	2.440	1.500	11.6352	23.8626	47.7253
10	2.815	1.7697	15.0557	41.6143	83.2285
11	3.375	1.7697	25.9457	94.1990	188.3981

$$A = \pi(R_o^2 - R_i^2)$$

$$I = \pi(R_o^4 - R_i^4)/4$$

$$J = 2I$$

AD-A183 988 LIGHTWEIGHT TOWED HOWITZER DEMONSTRATOR PHASE 1 AND 3/3
PARTIAL PHASE 2 VOLUM (U) FMC CORP MINNEAPOLIS MINN
NORTHERN ORDNANCE DIV R RATHE ET AL APR 87
UNCLASSIFIED FMC-E-3041-VOL-D1-PT-2 DAAA21-86-C-0047 F/G 19/6 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

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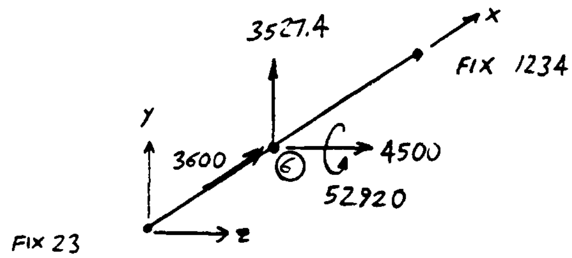
Minneapolis

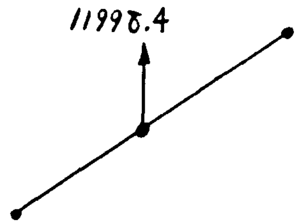
APPLIED MECHANICS

Subject	Analyst	
LTHD	JMF	
	Project Number	
	EC. No.	Date 2.25.87

LOADS - a) BUMP + SKID



b) 4.5G DROP



Sheet ___ Of ___

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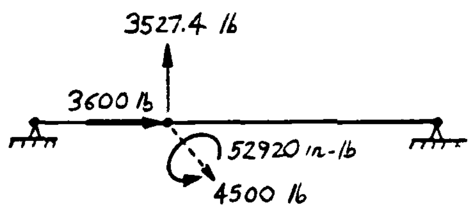
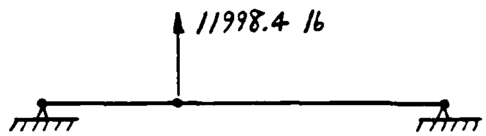
APPLIED MECHANICS

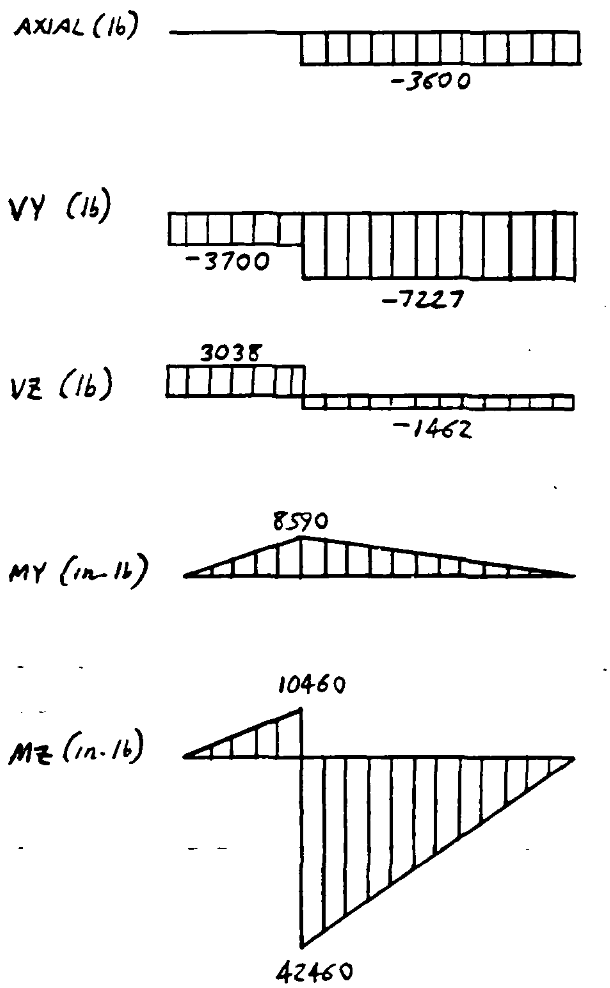
Subject	Analyst	
LTHD	JMZ	
	Project Number	
	EC. No.	Date 2-26-87

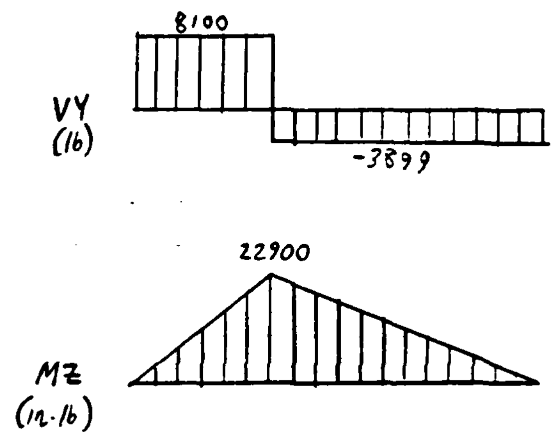
LC 1) BUMP & SKID



LC 2) 4.5G AIR DROP







MAX STRESS OCCURS IN LC 1, IN BARREL BEHIND WHEEL FLANGE (NODE 9, PROPERTY 7)

$AX = -3600 \qquad \sigma_A = \frac{3600}{6.88} = 524\ psi$

FOR ROUND TUBE:

$\left.\begin{array}{l} MY = 6031 \\ MZ = 29810 \end{array}\right\} \quad M = MY \mp MZ = 30414\ in\text{-}lb$

$\sigma_b = \frac{(30414\ in\text{-}lb)(2.44\ in)}{16.7138\ in^4} = 4440\ psi$

$\sigma_{MAX} = 4963\ psi$

6061-T6 $\sigma_Y = 35\ ksi$

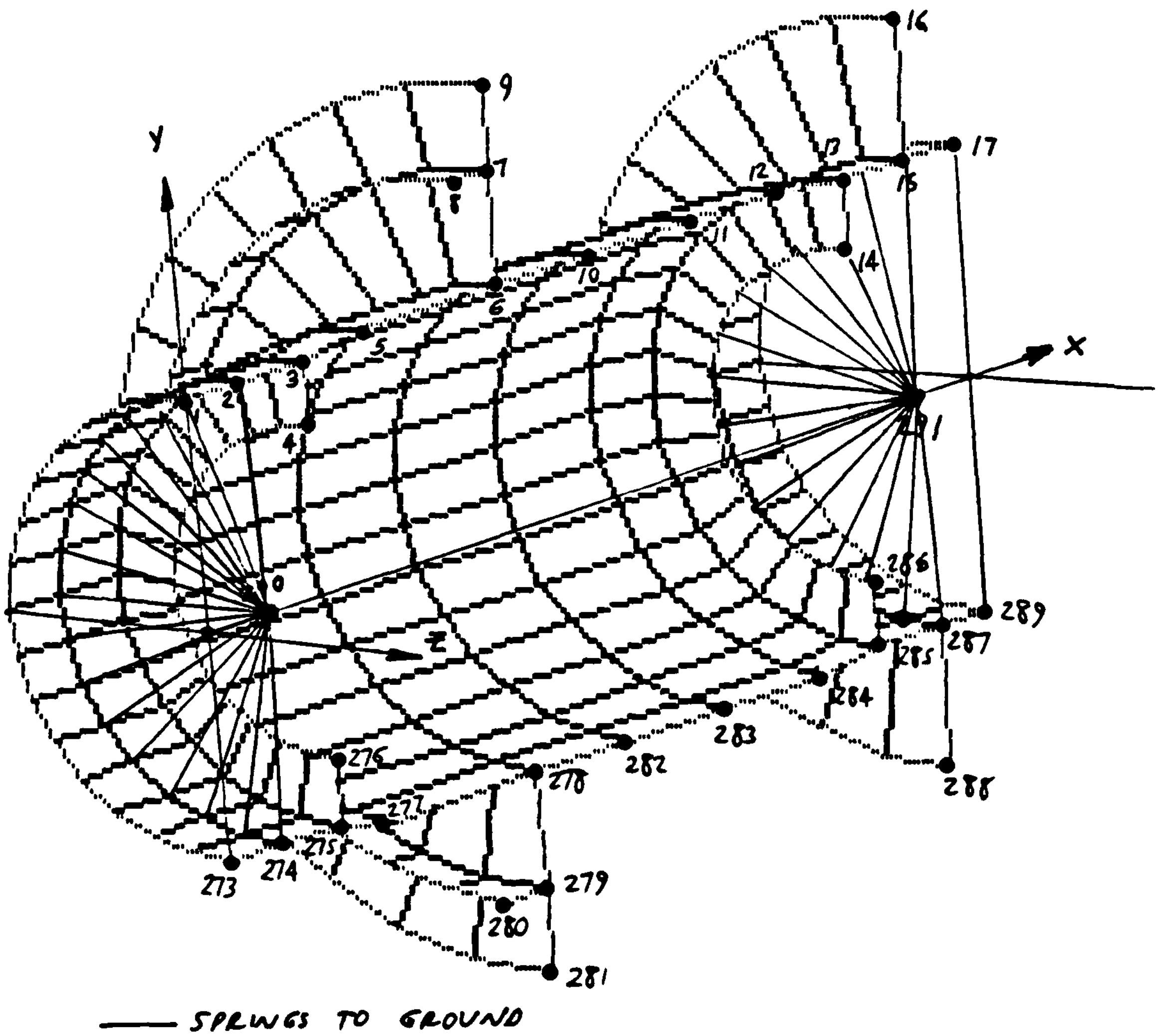
MAX σ_b FOR LC2 = 3223 PSI IN ELT. 5

FS = 10.86

$FS = \frac{35000}{4963} = 7.05$

Sheet ___ Of ___

LTHD HUB
PLATE MODEL

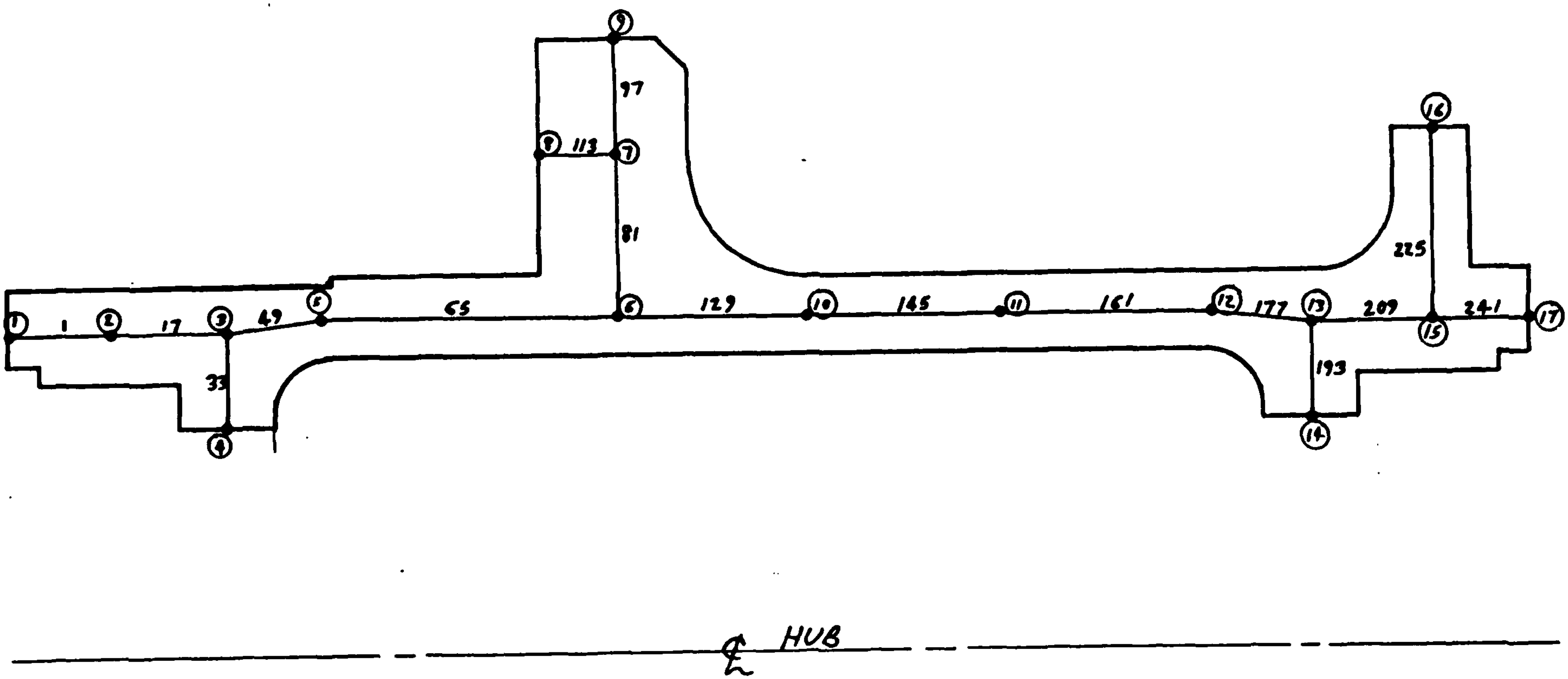


—— SPRINGS TO GROUND

- NODES 1-17, 273-289 FIXED 345

- NODES 15-287 x17 FIXED 1 (THRUST BRG.)

FIGURE 2


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
1
17
33
49
65
81
97
113
129
145
161
177
193
209
225
241
℄ HUB

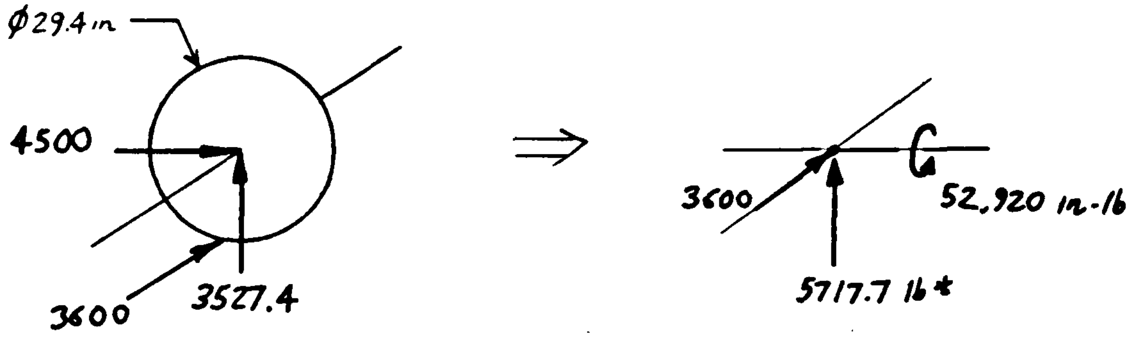
9

FMC Northern Ordnance Division
Minneapolis

APPLIED MECHANICS

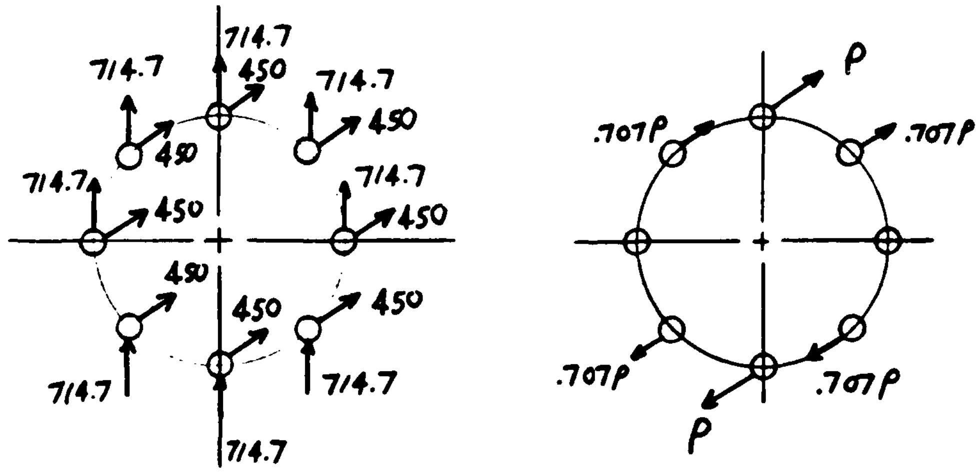
Subject	Analyst	
LTWD HUB	Project Number	
	EC. No.	Date 2-17-87

L.C. 1 BUMP & SKID



* LOAD ACTUALLY @ 51.9°, ASSUMED VERTICAL FOR SYMMETRIC MODEL

LOADING ON HUB BOLTS



P = 4071 lb
.707P = 2878 lb

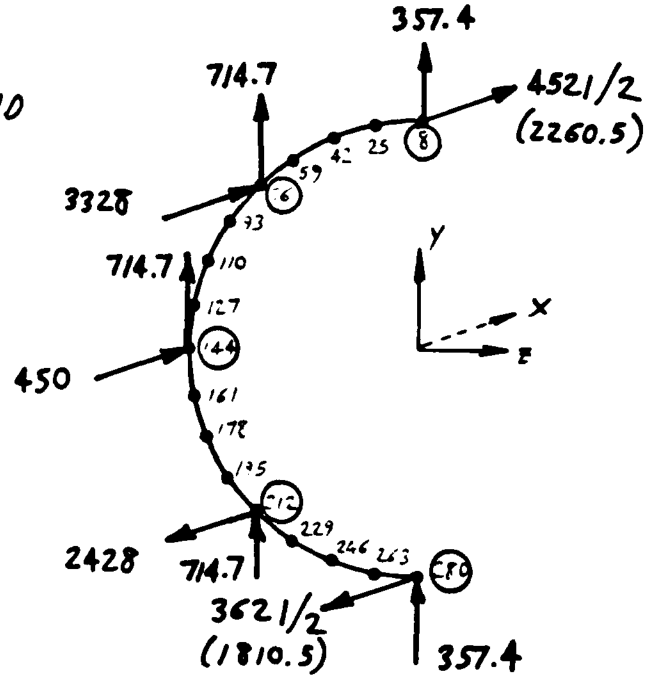
DA-649Oct85

FMC Northern Ordnance Division
Minneapolis

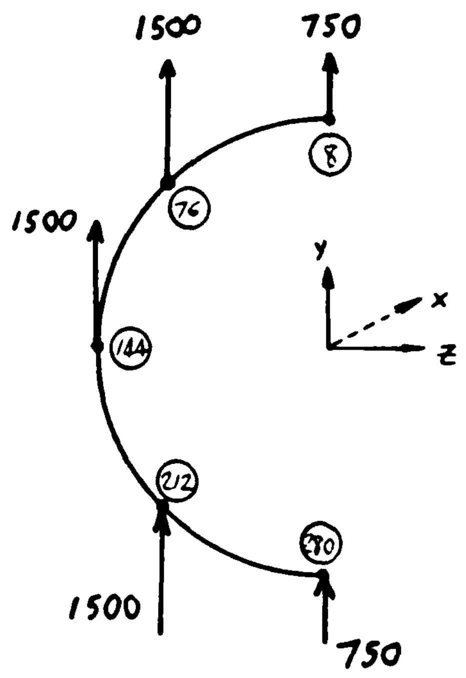
APPLIED MECHANICS

Subject	Analyst	
LTHD HUB	GMF	
	Project Number	
	EC. No.	Date 2-19-87

LC 1
BUMP + SKID

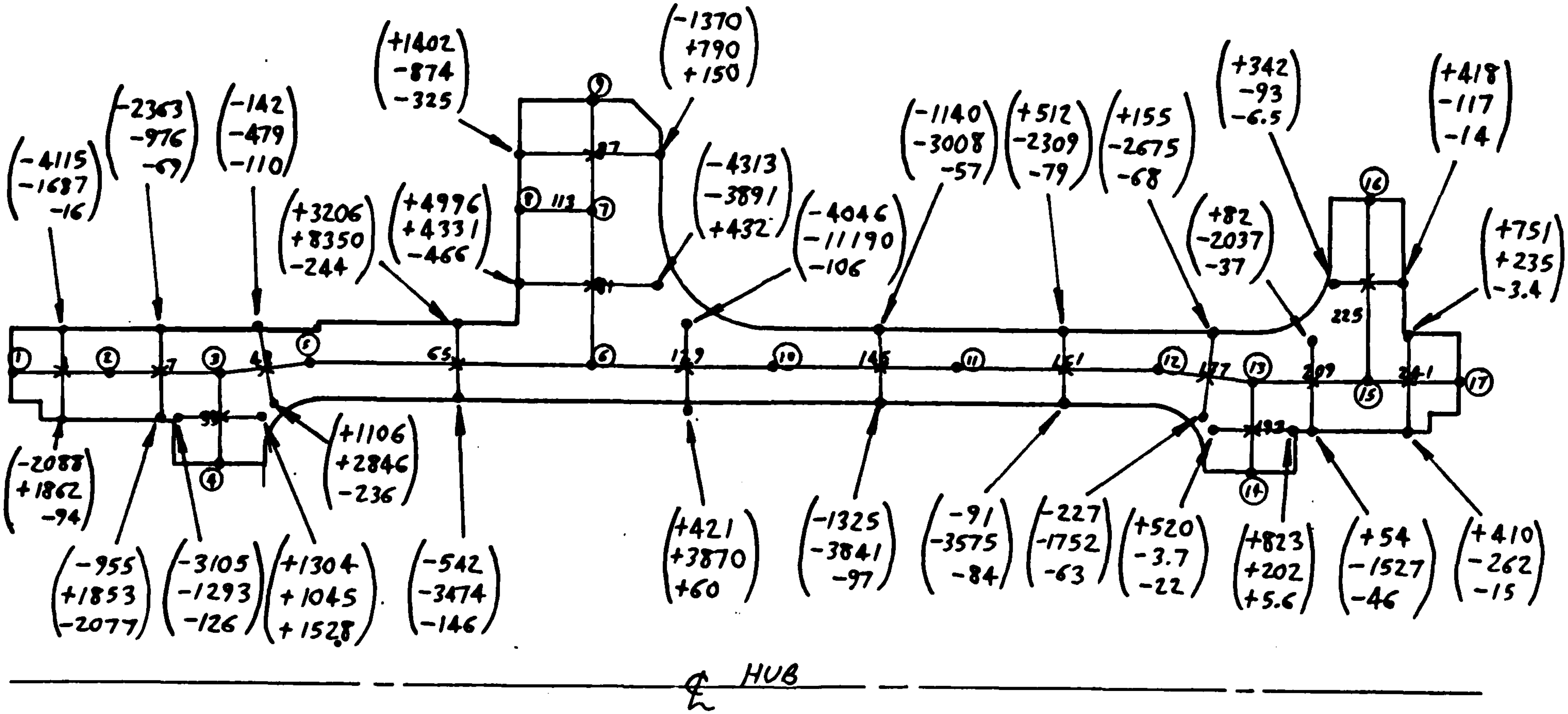


LC 2
AIR DROP



Sheet ___ Of ___

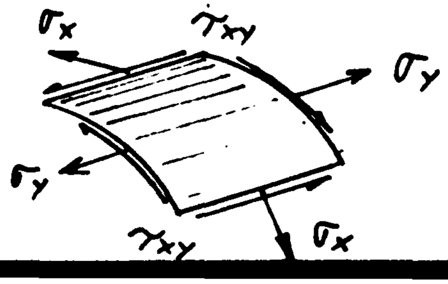
DA-649Oct86

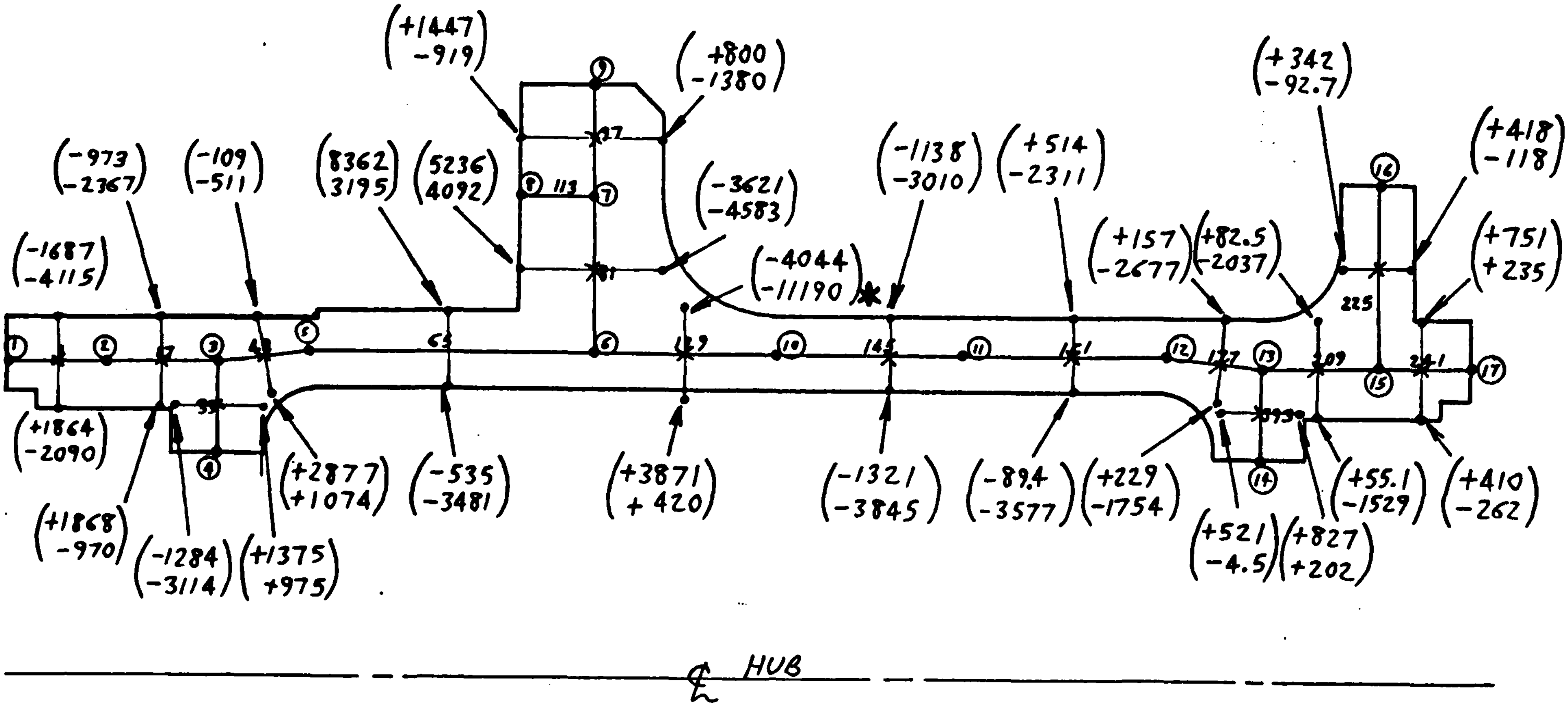


GENERAL STRESSES - LC 1

TOP ROW OF ELEMENTS

$\begin{pmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{pmatrix}$ HOOP / AXIAL OR RADIAL





PRINCIPAL STRESSES - LC 1

TOP ROW OF ELEMENTS

$\begin{pmatrix} \sigma_1 \\ \sigma_2 \end{pmatrix}$

* MAX. STRESS IN MODEL

```
================================================================================
============================ I M A G E S - 3 D =================================
================================================================================
 -25-1987                       Run ID=EB06212                         13:51:01
--------------------------------------------------------------------------------
!                                                                              !
! EEEEEEEEEE BBBBBBBB      000000      666666     222222       11      222222  !
! EEEEEEEEEE BBBBBBBB      000000      666666     222222       11      222222  !
! EE         BB      BB 00       00 66          22      22   1111    22      22 !
! EE         BB      BB 00       00 66          22      22   1111    22      22 !
! EE         BB      BB 00     0000 66                  22     11            22 !
! EE         BB      BB 00     0000 66                  22     11            22 !
! EEEEEEEE   BBBBBBBB   00   00  00 66666666          22       11          22  !
! EEEEEEEE   BBBBBBBB   00   00  00 66666666          22       11          22  !
! EE         BB      BB 0000     00 66      66      22         11        22    !
! EE         BB      BB 0000     00 66      66      22         11        22    !
! EE         BB      BB 00       00 66      66    22           11      22      !
! EE         BB      BB 00       00 66      66    22           11      22      !
! EEEEEEEEEE BBBBBBBB      000000      666666   2222222222   111111  2222222222 !
! EEEEEEEEEE BBBBBBBB      000000      666666   2222222222   111111  2222222222 !
!                                                                              !
--------------------------------------------------------------------------------
                       FMC CORPORATION  S/N:800484
```

```
!-------------------------------------------------!
!            J o b   I n f o r m a t i o n        !
!-------------------------------------------------!
!                                                 !
!       Project    : LTHD                         !
!                                                 !
!       Client     : _____________________        !
!                                                 !
!       Job Name   : _____________________        !
!                                                 !
!       Remarks    : Trail Wheel Hub              !
!                    Simple Beam Model            !
!                                                 !
!                                                 !
!       Engineer   : _______________/_________    !
!                    J. Fishbein                  !
!                                                 !
!       Chk'd by   : _______________/_________    !
!                                                 !
!                                                 !
!       Appr'd by  : _______________/_________    !
!                                                 !
!                                                 !
!       Comments   : _________________________    !
!                                                 !
!                    _________________________    !
!                                                 !
!-------------------------------------------------!
```

```
================================================================================
============================ I M A G E S - 3 D =================================
================================================================================
```

```
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Interactive Microcomputer Analysis & Graphics of Engineering Systems

            IMAGES-3D  Version 1.3  03/01/86

                    RUN ID=EB06212

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= applicability of the results obtained from   =
= IMAGES-3D.                                   =
================================================

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= of IMAGES-3D or the users manual should be   =
= addressed to:                                =
=                                              =
=           Celestial Software Inc.            =
=             125 University Ave.              =
=                Berkeley,CA                   =
=                   94710                      =
=                                              =
=                415-841-7175                  =
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FMC CORPORATION S/N:800484 02-25-1987

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============== I M A G E S 3 D ==============

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==

CHECK GEOMETRY Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

MATERIAL PROPERTIES

Material No	Modulus of Elasticity	Weight Density	Coeff of Thermal Exp.	Poisson's Ratio	Shear Web Modulus
1	1.00000E+07	1.00000E-01	0.00000E+00	3.00E-01	0.00000E+00

NODE COORDINATES

Node	X-Coord.	Y-Coord.	Z-Coord.
1	6.72300E-01	0.00000E+00	0.00000E+00
2	1.12000E+00	0.00000E+00	0.00000E+00
3	1.74500E+00	0.00000E+00	0.00000E+00
4	2.12000E+00	0.00000E+00	0.00000E+00
5	2.81000E+00	0.00000E+00	0.00000E+00
6	3.50000E+00	0.00000E+00	0.00000E+00
7	4.00000E+00	0.00000E+00	0.00000E+00
8	4.50000E+00	0.00000E+00	0.00000E+00
9	5.25000E+00	0.00000E+00	0.00000E+00
10	5.90630E+00	0.00000E+00	0.00000E+00
11	6.56250E+00	0.00000E+00	0.00000E+00
12	7.21880E+00	0.00000E+00	0.00000E+00
13	7.87500E+00	0.00000E+00	0.00000E+00
14	8.25000E+00	0.00000E+00	0.00000E+00
15	8.87500E+00	0.00000E+00	0.00000E+00
16	9.12500E+00	0.00000E+00	0.00000E+00
17	9.37500E+00	0.00000E+00	0.00000E+00

BEAM PROPERTIES

Multiplier = 1 (For AISC database properties only)

Prop No	X-Section Area	Moment of Inertia Iy /	Iz	Torsional Const.- J
1	8.347E+00	1.862E+01	1.862E+01	3.723E+01
2	1.112E+01	2.234E+01	2.234E+01	4.469E+01

CHECK GEOMETRY Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

Prop No	X-Section Area	Moment of Inertia Iy	/ Iz	Torsional Const.- J
3	8.565E+00	1.895E+01	1.895E+01	3.791E+01
4	7.126E+00	1.745E+01	1.745E+01	3.490E+01
5	3.844E+01	1.899E+02	1.899E+02	3.799E+02
6	1.307E+01	3.819E+01	3.819E+01	7.639E+01
7	6.880E+00	1.671E+01	1.671E+01	3.343E+01
8	9.083E+00	2.047E+01	2.047E+01	4.095E+01
9	1.164E+01	2.386E+01	2.386E+01	4.773E+01
10	1.506E+01	4.161E+01	4.161E+01	8.323E+01
11	2.595E+01	9.420E+01	9.420E+01	1.884E+02

Prop No	Max. Fiber Dist Cy	/ Cz	Shear Shape Fact SSFy	/ SSFz	Ctors
1	2.41E+00	2.41E+00	1.89E+00	1.89E+00	1.00E+00
2	2.41E+00	2.41E+00	1.89E+00	1.89E+00	1.00E+00
3	2.41E+00	2.41E+00	1.89E+00	1.89E+00	1.00E+00
4	2.46E+00	2.46E+00	1.89E+00	1.89E+00	1.00E+00
5	4.00E+00	4.00E+00	1.89E+00	1.89E+00	1.00E+00
6	2.82E+00	2.82E+00	1.89E+00	1.89E+00	1.00E+00
7	2.44E+00	2.44E+00	1.89E+00	1.89E+00	1.00E+00
8	2.44E+00	2.44E+00	1.89E+00	1.89E+00	1.00E+00
9	2.44E+00	2.44E+00	1.89E+00	1.89E+00	1.00E+00
10	2.82E+00	2.82E+00	1.89E+00	1.89E+00	1.00E+00
11	3.38E+00	3.38E+00	1.89E+00	1.89E+00	1.00E+00

BEAM CONNECTIVITY

Beam No	Nodes From/	To/	Ref	Prop No	Mat No	Pincodes I / J	Length	Y Dir Cosines X	Y	Z	Beam Type
1	1	2	0	1	1		4.477E-01	0.00	1.00	0.00	Beam
2	2	3	0	2	1		6.250E-01	0.00	1.00	0.00	Beam
3	3	4	0	3	1		3.750E-01	0.00	1.00	0.00	Beam
4	4	5	0	4	1		6.900E-01	0.00	1.00	0.00	Beam
5	5	6	0	4	1		6.900E-01	0.00	1.00	0.00	Beam
6	6	7	0	5	1		5.000E-01	0.00	1.00	0.00	Beam
7	7	8	0	5	1		5.000E-01	0.00	1.00	0.00	Beam
8	8	9	0	6	1		7.500E-01	0.00	1.00	0.00	Beam
9	9	10	0	7	1		6.563E-01	0.00	1.00	0.00	Beam

CHECK GEOMETRY Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

Beam No	Nodes From/	To/Ref		Prop No	Mat No	Pincodes I / J	Length	Y Dir Cosines X	Y	Z	Beam Type
10	10	11	0	7	1		6.562E-01	0.00	1.00	0.00	Beam
11	11	12	0	7	1		6.563E-01	0.00	1.00	0.00	Beam
12	12	13	0	7	1		6.562E-01	0.00	1.00	0.00	Beam
13	13	14	0	8	1		3.750E-01	0.00	1.00	0.00	Beam
14	14	15	0	9	1		6.250E-01	0.00	1.00	0.00	Beam
15	15	16	0	10	1		2.500E-01	0.00	1.00	0.00	Beam
16	16	17	0	11	1		2.500E-01	0.00	1.00	0.00	Beam

RESTRAINTS

Node No	Restraint Directions
1	- Y Z - - -
17	X Y Z RX - -

RENUMBER NODES Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

Node Renumbering Cross Reference List

Was	Is	Was	Is	Was	Is
1	1	2	2	3	3
4	4	5	5	6	6
7	7	8	8	9	9
10	10	11	11	12	12
13	13	14	14	15	15
16	16	17	17		

Original Nodal Band 2
Final Nodal band 2

```
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ASSEMBLE STIFFNESS MATRIX  Version 1.3  03/01/86

LTHD Wheel Hub -- Simple Beam Model

STIFFNESS ASSEMBLY SUMMARY

Number of Node Points.................  17
Number of Truss and Beam Elements.....  16
Number of Plate Elements..............   0
Number of Spring Elements.............   0
Number of Nodes with Restraints.......   2
Number of Blocks in the Matrix........   1

BLOCK NUMBER  1

FORM Matrix
PACK Matrix
Size =    5776 Bytes
TRIANGULARIZE Matrix

Number of terms in the matrix.       722
Largest column................        11
Minimum Diagonal Stiffness =   .4189616D+08
Maximum Diagonal Stiffness =   .7617020D+10
```

ASSEMBLE STIFFNESS MATRIX Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

C R O S S R E F E R E N C E L I S T

Is Node Verus Internal Equation Number

Is	TRANSLATION			ROTATION		
Node	Eqn.	Eqn.	Eqn.	Eqn.	Eqn.	Eqn.
1	1			2	3	4
2	5	6	7	8	9	10
3	11	12	13	14	15	16
4	17	18	19	20	21	22
5	23	24	25	26	27	28
6	29	30	31	32	33	34
7	35	36	37	38	39	40
8	41	42	43	44	45	46
9	47	48	49	50	51	52
10	53	54	55	56	57	58
11	59	60	61	62	63	64
12	65	66	67	68	69	70
13	71	72	73	74	75	76
14	77	78	79	80	81	82
15	83	84	85	86	87	88
16	89	90	91	92	93	94
17					95	96

2 2

TMC CORPORATION   S/N:800484

02-25-87
PAGE 1

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SOLVE DISPLACEMENTS   Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

L O A D C A S E 1

Bump and Skid

CONCENTRATED LOADS

Node	Fx	Fy	Fz	Mx	My	Mz
6	.3600E+04	.3527E+04	.4500E+04	.0000E+00	.0000E+00	.5292E+05

SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

L O A D C A S E 1

Bump and Skid

APPLIED LOAD VECTOR

Node	Fx	Fy	Fz	Mx	My	Mz
6	.3600E+04	.3527E+04	.4500E+04	.0000E+00	.0000E+00	.5292E+05

SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

L O A D C A S E 1

Bump and Skid

DISPLACEMENTS

	Translations			/	Rotations		
Node	X	Y	Z	/	X	Y	Z
1	.2110E-03	.0000E+00	.0000E+00	/	.0000E+00	-.7354E-04	.4088E-03
2	.2110E-03	.8581E-04	.1127E-03	/	.0000E+00	-.7190E-04	.4108E-03
3	.2110E-03	.2425E-03	.2399E-03	/	.0000E+00	-.6544E-04	.4187E-03
4	.2110E-03	.3215E-03	.3284E-03	/	.0000E+00	-.5787E-04	.4279E-03
5	.2110E-03	.4492E-03	.5059E-03	/	.0000E+00	-.3634E-04	.4541E-03
6	.2110E-03	.5985E-03	.6657E-03	/	.0000E+00	-.6516E-05	.4904E-03
7	.2063E-03	.7948E-03	.6591E-03	/	.0000E+00	-.4351E-05	.4797E-03
8	.2017E-03	.9860E-03	.6514E-03	/	.0000E+00	-.2378E-05	.4700E-03
9	.1810E-03	.1110E-02	.6070E-03	/	.0000E+00	.1054E-04	.4061E-03
10	.1467E-03	.1001E-02	.5242E-03	/	.0000E+00	.3234E-04	.2984E-03
11	.1123E-03	.8283E-03	.4283E-03	/	.0000E+00	.5037E-04	.2093E-03
12	.7798E-04	.6027E-03	.3218E-03	/	.0000E+00	.6463E-04	.1388E-03
13	.4365E-04	.3370E-03	.2072E-03	/	.0000E+00	.7513E-04	.8688E-04
14	.2878E-04	.2195E-03	.1487E-03	/	.0000E+00	.7864E-04	.6951E-04
15	.9447E-05	.6680E-04	.5987E-04	/	.0000E+00	.8176E-04	.5413E-04
16	.3469E-05	.2113E-04	.2745E-04	/	.0000E+00	.8208E-04	.5250E-04
17	.0000E+00	.0000E+00	.0000E+00	/	.0000E+00	.8213E-04	.5226E-04

SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

L O A D C A S E 2

4.5G Air Drop

CONCENTRATED LOADS

Node	Fx	Fy	Fz	Mx	My	Mz
6	.0000E+00	.1200E+05	.0000E+00	.0000E+00	.0000E+00	.0000E+00

27

SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

L O A D C A S E 2

4.5G Air Drop

APPLIED LOAD VECTOR

Node	Fx	Fy	Fz	Mx	My	Mz
6	.0000E+00	.1200E+05	.0000E+00	.0000E+00	.0000E+00	.0000E+00

SOLVE DISPLACEMENTS Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

L O A D C A S E 2

4.5G Air Drop

DISPLACEMENTS

	Translations			/	Rotations		
Node	X	Y	Z	/	X	Y	Z
1	.0000E+00	.0000E+00	.0000E+00	/	.0000E+00	.0000E+00	.1961E-03
2	.0000E+00	.3006E-03	.0000E+00	/	.0000E+00	.0000E+00	.1917E-03
3	.0000E+00	.6396E-03	.0000E+00	/	.0000E+00	.0000E+00	.1745E-03
4	.0000E+00	.8757E-03	.0000E+00	/	.0000E+00	.0000E+00	.1543E-03
5	.0000E+00	.1349E-02	.0000E+00	/	.0000E+00	.0000E+00	.9688E-04
6	.0000E+00	.1775E-02	.0000E+00	/	.0000E+00	.0000E+00	.1737E-04
7	.0000E+00	.1757E-02	.0000E+00	/	.0000E+00	.0000E+00	.1160E-04
8	.0000E+00	.1737E-02	.0000E+00	/	.0000E+00	.0000E+00	.6340E-05
9	.0000E+00	.1618E-02	.0000E+00	/	.0000E+00	.0000E+00	-.2811E-04
10	.0000E+00	.1398E-02	.0000E+00	/	.0000E+00	.0000E+00	-.8623E-04
11	.0000E+00	.1142E-02	.0000E+00	/	.0000E+00	.0000E+00	-.1343E-03
12	.0000E+00	.8581E-03	.0000E+00	/	.0000E+00	.0000E+00	-.1723E-03
13	.0000E+00	.5526E-03	.0000E+00	/	.0000E+00	.0000E+00	-.2003E-03
14	.0000E+00	.3965E-03	.0000E+00	/	.0000E+00	.0000E+00	-.2097E-03
15	.0000E+00	.1596E-03	.0000E+00	/	.0000E+00	.0000E+00	-.2180E-03
16	.0000E+00	.7320E-04	.0000E+00	/	.0000E+00	.0000E+00	-.2189E-03
17	.0000E+00	.0000E+00	.0000E+00	/	.0000E+00	.0000E+00	-.2190E-03

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

Load Case 1: Bump and Skid

BEAM LOADS AND/OR STRESSES

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
				BEAM NO. 1			
LLoads	1	.1414E-11	.3700E+04	-.3038E+04	.0000E+00	-.7052E-11	-.1266E-08
LLoads	2	-.1414E-11	-.3700E+04	.3038E+04	.0000E+00	.1360E+04	.1656E+04
Stress	1	-.1694E-12	.8377E+03	-.6878E+03	.0000E+00	.1636E-09	.9115E-12
Stress	2	-.1694E-12	.8377E+03	-.6878E+03	.0000E+00	.2141E+03	.1758E+03
				BEAM NO. 2			
LLoads	2	.2707E-11	.3700E+04	-.3038E+04	.0000E+00	-.1360E+04	-.1656E+04
LLoads	3	-.2707E-11	-.3700E+04	.3038E+04	.0000E+00	.3259E+04	.3969E+04
Stress	2	-.2435E-12	.6289E+03	-.5164E+03	.0000E+00	.1784E+03	.1465E+03
Stress	3	-.2435E-12	.6289E+03	-.5164E+03	.0000E+00	.4274E+03	.3509E+03
				BEAM NO. 3			
LLoads	3	-.5400E-12	.3700E+04	-.3038E+04	.0000E+00	-.3259E+04	-.3969E+04
LLoads	4	.5400E-12	-.3700E+04	.3038E+04	.0000E+00	.4398E+04	.5356E+04
Stress	3	.6305E-13	.8164E+03	-.6703E+03	.0000E+00	.5038E+03	.4137E+03
Stress	4	.6305E-13	.8164E+03	-.6703E+03	.0000E+00	.6799E+03	.5583E+03
				BEAM NO. 4			
LLoads	4	-.8669E-12	.3700E+04	-.3038E+04	.0000E+00	-.4398E+04	-.5356E+04
LLoads	5	.8669E-12	-.3700E+04	.3038E+04	.0000E+00	.6494E+04	.7909E+04
Stress	4	.1216E-12	.9812E+03	-.8057E+03	.0000E+00	.7538E+03	.6189E+03
Stress	5	.1216E-12	.9812E+03	-.8057E+03	.0000E+00	.1113E+04	.9139E+03
				BEAM NO. 5			
LLoads	5	-.8669E-12	.3700E+04	-.3038E+04	.0000E+00	-.6494E+04	-.7909E+04
LLoads	6	.8669E-12	-.3700E+04	.3038E+04	.0000E+00	.8590E+04	.1046E+05
Stress	5	.1216E-12	.9812E+03	-.8057E+03	.0000E+00	.1113E+04	.9139E+03
Stress	6	.1216E-12	.9812E+03	-.8057E+03	.0000E+00	.1472E+04	.1209E+04
				BEAM NO. 6			
LLoads	6	.3600E+04	.7227E+04	.1462E+04	.0000E+00	-.8590E+04	.4246E+05
LLoads	7	-.3600E+04	-.7227E+04	-.1462E+04	.0000E+00	.7859E+04	-.3885E+05
Stress	6	-.9365E+02	.3553E+03	.7189E+02	.0000E+00	-.8942E+03	.1809E+03
Stress	7	-.9365E+02	.3553E+03	.7189E+02	.0000E+00	-.8181E+03	.1655E+03
				BEAM NO. 7			
LLoads	7	.3600E+04	.7227E+04	.1462E+04	.0000E+00	-.7859E+04	.3885E+05
LLoads	8	-.3600E+04	-.7227E+04	-.1462E+04	.0000E+00	.7128E+04	-.3523E+05
Stress	7	-.9365E+02	.3553E+03	.7189E+02	.0000E+00	-.8181E+03	.1655E+03
Stress	8	-.9365E+02	.3553E+03	.7189E+02	.0000E+00	-.7420E+03	.1501E+03
				BEAM NO. 8			
LLoads	8	.3600E+04	.7227E+04	.1462E+04	.0000E+00	-.7128E+04	.3523E+05
LLoads	9	-.3600E+04	-.7227E+04	-.1462E+04	.0000E+00	.6031E+04	-.2981E+05
Stress	8	-.2754E+03	.1045E+04	.2114E+03	.0000E+00	-.2597E+04	.5254E+03
Stress	9	-.2754E+03	.1045E+04	.2114E+03	.0000E+00	-.2197E+04	.4445E+03

SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

Load Case 1: Bump and Skid

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
BEAM NO. 9							
LLoads	9	.3600E+04	.7227E+04	.1462E+04	.0000E+00	-.6031E+04	.2981E+05
LLoads	10	-.3600E+04	-.7227E+04	-.1462E+04	.0000E+00	.5072E+04	-.2507E+05
Stress	9	-.5232E+03	.1985E+04	.4017E+03	.0000E+00	-.4352E+04	.8805E+03
Stress	10	-.5232E+03	.1985E+04	.4017E+03	.0000E+00	-.3660E+04	.7404E+03
BEAM NO. 10							
LLoads	10	.3600E+04	.7227E+04	.1462E+04	.0000E+00	-.5072E+04	.2507E+05
LLoads	11	-.3600E+04	-.7227E+04	-.1462E+04	.0000E+00	.4112E+04	-.2033E+05
Stress	10	-.5232E+03	.1985E+04	.4017E+03	.0000E+00	-.3660E+04	.7404E+03
Stress	11	-.5232E+03	.1985E+04	.4017E+03	.0000E+00	-.2967E+04	.6003E+03
BEAM NO. 11							
LLoads	11	.3600E+04	.7227E+04	.1462E+04	.0000E+00	-.4112E+04	.2033E+05
LLoads	12	-.3600E+04	-.7227E+04	-.1462E+04	.0000E+00	.3153E+04	-.1558E+05
Stress	11	-.5232E+03	.1985E+04	.4017E+03	.0000E+00	-.2967E+04	.6003E+03
Stress	12	-.5232E+03	.1985E+04	.4017E+03	.0000E+00	-.2275E+04	.4603E+03
BEAM NO. 12							
LLoads	12	.3600E+04	.7227E+04	.1462E+04	.0000E+00	-.3153E+04	.1558E+05
LLoads	13	-.3600E+04	-.7227E+04	-.1462E+04	.0000E+00	.2193E+04	-.1084E+05
Stress	12	-.5232E+03	.1985E+04	.4017E+03	.0000E+00	-.2275E+04	.4603E+03
Stress	13	-.5232E+03	.1985E+04	.4017E+03	.0000E+00	-.1583E+04	.3202E+03
BEAM NO. 13							
LLoads	13	.3600E+04	.7227E+04	.1462E+04	.0000E+00	-.2193E+04	.1084E+05
LLoads	14	-.3600E+04	-.7227E+04	-.1462E+04	.0000E+00	.1645E+04	-.8130E+04
Stress	13	-.3964E+03	.1504E+04	.3043E+03	.0000E+00	-.1292E+04	.2614E+03
Stress	14	-.3964E+03	.1504E+04	.3043E+03	.0000E+00	-.9690E+03	.1960E+03
BEAM NO. 14							
LLoads	14	.3600E+04	.7227E+04	.1462E+04	.0000E+00	-.1645E+04	.8130E+04
LLoads	15	-.3600E+04	-.7227E+04	-.1462E+04	.0000E+00	.7311E+03	-.3614E+04
Stress	14	-.3094E+03	.1174E+04	.2375E+03	.0000E+00	-.8313E+03	.1682E+03
Stress	15	-.3094E+03	.1174E+04	.2375E+03	.0000E+00	-.3695E+03	.7475E+02
BEAM NO. 15							
LLoads	15	.3600E+04	.7227E+04	.1462E+04	.0000E+00	-.7311E+03	.3614E+04
LLoads	16	-.3600E+04	-.7227E+04	-.1462E+04	.0000E+00	.3655E+03	-.1807E+04
Stress	15	-.2391E+03	.9072E+03	.1835E+03	.0000E+00	-.2444E+03	.4945E+02
Stress	16	-.2391E+03	.9072E+03	.1835E+03	.0000E+00	-.1222E+03	.2473E+02
BEAM NO. 16							
LLoads	16	.3600E+04	.7227E+04	.1462E+04	.0000E+00	-.3655E+03	.1807E+04
LLoads	17	-.3600E+04	-.7227E+04	-.1462E+04	.0000E+00	.7134E-09	.2579E-08
Stress	16	-.1388E+03	.5264E+03	.1065E+03	.0000E+00	-.6473E+02	.1310E+02
Stress	17	-.1388E+03	.5264E+03	.1065E+03	.0000E+00	.9242E-10	.2556E-10

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

Load Case 1: Bump and Skid

MAXIMUM STRESS SUMMARY FOR BEAMS/TRUSSES
WITHIN SPECIFIED RANGE 1- 16

Maximum (absolute) Stress = .4352E+04 at BEAM 9

Beam	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
9	-.5232E+03	.1985E+04	.4017E+03	.0000E+00	-.4352E+04	.8805E+03

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SOLVE REACTIONS Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

Load Case 1: Bump and Skid

REACTIONS

Node	Fx	Fy	Fz	Mx	My	Mz
1	.0000E+00	.3700E+04	-.3038E+04	.0000E+00	.0000E+00	.0000E+00
17	-.3600E+04	-.7227E+04	-.1462E+04	.0000E+00	.0000E+00	.0000E+00

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

Load Case 2: 4.5G Air Drop

BEAM LOADS AND/OR STRESSES

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
			BEAM NO. 1				
LLoads	1	.0000E+00	-.8100E+04	.0000E+00	.0000E+00	.0000E+00	-.1960E-08
LLoads	2	.0000E+00	.8100E+04	.0000E+00	.0000E+00	.0000E+00	-.3626E+04
Stress	1	.0000E+00	-.1834E+04	.0000E+00	.0000E+00	.2533E-09	.0000E+00
Stress	2	.0000E+00	-.1834E+04	.0000E+00	.0000E+00	-.4687E+03	.0000E+00
			BEAM NO. 2				
LLoads	2	.0000E+00	-.8100E+04	.0000E+00	.0000E+00	.0000E+00	.3626E+04
LLoads	3	.0000E+00	.8100E+04	.0000E+00	.0000E+00	.0000E+00	-.8689E+04
Stress	2	.0000E+00	-.1377E+04	.0000E+00	.0000E+00	-.3905E+03	.0000E+00
Stress	3	.0000E+00	-.1377E+04	.0000E+00	.0000E+00	-.9356E+03	.0000E+00
			BEAM NO. 3				
LLoads	3	.0000E+00	-.8100E+04	.0000E+00	.0000E+00	.0000E+00	.8689E+04
LLoads	4	.0000E+00	.8100E+04	.0000E+00	.0000E+00	.0000E+00	-.1173E+05
Stress	3	.0000E+00	-.1787E+04	.0000E+00	.0000E+00	-.1103E+04	.0000E+00
Stress	4	.0000E+00	-.1787E+04	.0000E+00	.0000E+00	-.1489E+04	.0000E+00
			BEAM NO. 4				
LLoads	4	.0000E+00	-.8100E+04	.0000E+00	.0000E+00	.0000E+00	.1173E+05
LLoads	5	.0000E+00	.8100E+04	.0000E+00	.0000E+00	.0000E+00	-.1732E+05
Stress	4	.0000E+00	-.2148E+04	.0000E+00	.0000E+00	-.1650E+04	.0000E+00
Stress	5	.0000E+00	-.2148E+04	.0000E+00	.0000E+00	-.2437E+04	.0000E+00
			BEAM NO. 5				
LLoads	5	.0000E+00	-.8100E+04	.0000E+00	.0000E+00	.0000E+00	.1732E+05
LLoads	6	.0000E+00	.8100E+04	.0000E+00	.0000E+00	.0000E+00	-.2290E+05
Stress	5	.0000E+00	-.2148E+04	.0000E+00	.0000E+00	-.2437E+04	.0000E+00
Stress	6	.0000E+00	-.2148E+04	.0000E+00	.0000E+00	-.3223E+04	.0000E+00
			BEAM NO. 6				
LLoads	6	.0000E+00	.3899E+04	.0000E+00	.0000E+00	.0000E+00	.2290E+05
LLoads	7	.0000E+00	-.3899E+04	.0000E+00	.0000E+00	.0000E+00	-.2095E+05
Stress	6	.0000E+00	.1917E+03	.0000E+00	.0000E+00	-.4823E+03	.0000E+00
Stress	7	.0000E+00	.1917E+03	.0000E+00	.0000E+00	-.4413E+03	.0000E+00
			BEAM NO. 7				
LLoads	7	.0000E+00	.3899E+04	.0000E+00	.0000E+00	.0000E+00	.2095E+05
LLoads	8	.0000E+00	-.3899E+04	.0000E+00	.0000E+00	.0000E+00	-.1901E+05
Stress	7	.0000E+00	.1917E+03	.0000E+00	.0000E+00	-.4413E+03	.0000E+00
Stress	8	.0000E+00	.1917E+03	.0000E+00	.0000E+00	-.4002E+03	.0000E+00
			BEAM NO. 8				
LLoads	8	.0000E+00	.3899E+04	.0000E+00	.0000E+00	.0000E+00	.1901E+05
LLoads	9	.0000E+00	-.3899E+04	.0000E+00	.0000E+00	.0000E+00	-.1608E+05
Stress	8	.0000E+00	.5637E+03	.0000E+00	.0000E+00	-.1401E+04	.0000E+00
Stress	9	.0000E+00	.5637E+03	.0000E+00	.0000E+00	-.1185E+04	.0000E+00

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

Load Case 2: 4.5G Air Drop

LLoads /Stress	Node	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
				BEAM NO. 9			
LLoads	9	.0000E+00	.3899E+04	.0000E+00	.0000E+00	.0000E+00	.1608E+05
LLoads	10	.0000E+00	-.3899E+04	.0000E+00	.0000E+00	.0000E+00	-.1352E+05
Stress	9	.0000E+00	.1071E+04	.0000E+00	.0000E+00	-.2348E+04	.0000E+00
Stress	10	.0000E+00	.1071E+04	.0000E+00	.0000E+00	-.1974E+04	.0000E+00
				BEAM NO. 10			
LLoads	10	.0000E+00	.3899E+04	.0000E+00	.0000E+00	.0000E+00	.1352E+05
LLoads	11	.0000E+00	-.3899E+04	.0000E+00	.0000E+00	.0000E+00	-.1096E+05
Stress	10	.0000E+00	.1071E+04	.0000E+00	.0000E+00	-.1974E+04	.0000E+00
Stress	11	.0000E+00	.1071E+04	.0000E+00	.0000E+00	-.1601E+04	.0000E+00
				BEAM NO. 11			
LLoads	11	.0000E+00	.3899E+04	.0000E+00	.0000E+00	.0000E+00	.1096E+05
LLoads	12	.0000E+00	-.3899E+04	.0000E+00	.0000E+00	.0000E+00	-.8406E+04
Stress	11	.0000E+00	.1071E+04	.0000E+00	.0000E+00	-.1601E+04	.0000E+00
Stress	12	.0000E+00	.1071E+04	.0000E+00	.0000E+00	-.1227E+04	.0000E+00
				BEAM NO. 12			
LLoads	12	.0000E+00	.3899E+04	.0000E+00	.0000E+00	.0000E+00	.8406E+04
LLoads	13	.0000E+00	-.3899E+04	.0000E+00	.0000E+00	.0000E+00	-.5848E+04
Stress	12	.0000E+00	.1071E+04	.0000E+00	.0000E+00	-.1227E+04	.0000E+00
Stress	13	.0000E+00	.1071E+04	.0000E+00	.0000E+00	-.8537E+03	.0000E+00
				BEAM NO. 13			
LLoads	13	.0000E+00	.3899E+04	.0000E+00	.0000E+00	.0000E+00	.5848E+04
LLoads	14	.0000E+00	-.3899E+04	.0000E+00	.0000E+00	.0000E+00	-.4386E+04
Stress	13	.0000E+00	.8112E+03	.0000E+00	.0000E+00	-.6970E+03	.0000E+00
Stress	14	.0000E+00	.8112E+03	.0000E+00	.0000E+00	-.5227E+03	.0000E+00
				BEAM NO. 14			
LLoads	14	.0000E+00	.3899E+04	.0000E+00	.0000E+00	.0000E+00	.4386E+04
LLoads	15	.0000E+00	-.3899E+04	.0000E+00	.0000E+00	.0000E+00	-.1949E+04
Stress	14	.0000E+00	.6333E+03	.0000E+00	.0000E+00	-.4485E+03	.0000E+00
Stress	15	.0000E+00	.6333E+03	.0000E+00	.0000E+00	-.1993E+03	.0000E+00
				BEAM NO. 15			
LLoads	15	.0000E+00	.3899E+04	.0000E+00	.0000E+00	.0000E+00	.1949E+04
LLoads	16	.0000E+00	-.3899E+04	.0000E+00	.0000E+00	.0000E+00	-.9746E+03
Stress	15	.0000E+00	.4894E+03	.0000E+00	.0000E+00	-.1319E+03	.0000E+00
Stress	16	.0000E+00	.4894E+03	.0000E+00	.0000E+00	-.6593E+02	.0000E+00
				BEAM NO. 16			
LLoads	16	.0000E+00	.3899E+04	.0000E+00	.0000E+00	.0000E+00	.9746E+03
LLoads	17	.0000E+00	-.3899E+04	.0000E+00	.0000E+00	.0000E+00	.1743E-08
Stress	16	.0000E+00	.2840E+03	.0000E+00	.0000E+00	-.3492E+02	.0000E+00
Stress	17	.0000E+00	.2840E+03	.0000E+00	.0000E+00	.6244E-10	.0000E+00

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SOLVE BEAM LOADS/STRESSES Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

Load Case 2: 4.5G Air Drop

MAXIMUM STRESS SUMMARY FOR BEAMS/TRUSSES
WITHIN SPECIFIED RANGE 1- 16

Maximum (absolute) Stress = .3223E+04 at BEAM 5

Beam	Axial	Y-Shear	Z-Shear	Torsion	Y-Bending	Z-Bending
5	.0000E+00	-.2148E+04	.0000E+00	.0000E+00	-.3223E+04	.0000E+00

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SOLVE REACTIONS Version 1.3 03/01/86

LTHD Wheel Hub -- Simple Beam Model

Load Case 2: 4.5G Air Drop

REACTIONS

Node	Fx	Fy	Fz	Mx	My	Mz
1	.0000E+00	-.8100E+04	.0000E+00	.0000E+00	.0000E+00	.0000E+00
17	.0000E+00	-.3899E+04	.0000E+00	.0000E+00	.0000E+00	.0000E+00

END

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